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New Challenges for a New Era

Progress Through Innovation, Education and Research in North Carolina

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Final Report
of the
Governor's Task Force on Science and Technology

VOLUME III
RESEARCH AND HIGHER EDUCATION: BUILDING A FOUNDATION FOR INNOVATION

N.C. Board of Science and Technology
Office of the Governor
Raleigh, North Carolina
January, 1984

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PREFACE

The underlying theme of Volume III is expressed in its title: "Building a Foundation for Innovation." Entrepreneurship is primarily the domain of private individuals and companies operating in the profit-driven marketplace. Nevertheless, the coming of a technological future has made higher education's supporting role increasingly important, even essential. In the decades ahead, advanced education and academic research will be the source of the raw materials -- trained manpower and new ideas -- that will fuel economic development. The recommendations of this Volume are directed toward strengthening the base for technological growth within North Carolina's colleges, universities and community colleges.

Our strategy for building a research, education and training system to support innovation encompasses six broad themes:

First, we must achieve a high level of scientific and technical literacy for all students. In the workplace of the future, skilled and technical workers, as well as professional scientists and engineers, will need a thorough understanding of scientific and technical basics to handle the complex tools of advanced production. Furthermore, they will need the flexibility to retrain and to adapt to new technologies, which will only be possible if they first have a good grounding in science and mathematics. Volume IV, "Public Education and the Technological Challenge," addresses this need at the elementary and secondary level. Higher education can also contribute by toughening entrance and graduation standards and improving the quality of academic counseling.

Second, we must fully educate students for life as well as work. North Carolina cannot overlook the broader purpose of higher education, as articulated during a Task Force Conference: "to think, to live, and to enjoy life." Technical understanding will be a prerequisite to full participation in the 20th century, but it must be illuminated with the wisdom of the social sciences and humanities. The institutions that educate undergraduates, particularly, bear a responsibility for providing a broad education that will instill in their students a capacity for informed, humanitarian decisionmaking and personal growth.

Third, we must have the most accurate and current information about jobs. Colleges, universities and community colleges can be a potent force in North Carolina's adaptation to evolving labor needs, but only if they can anticipate direction of labor force changes. While no information system can perfectly foresee the future, a system that combines the best available forecasting techniques with a capacity to conduct in-depth studies of critical labor market segments will greatly enhance North Carolina's ability to manage and benefit from labor market shifts. Furthermore, such a system will help identify groups of workers requiring special attention and assistance; those whose jobs are displaced by technology, for example.

Fourth, we must maintain a base of excellence in all our institutions of higher education, particularly in the scientific and technical fields. Our public and private colleges, universities and community colleges must attract and retain the finest instructors and faculty members by paying them salaries commensurate with those in private industry. We must also provide our institutions with the specialized equipment and facilities needed for scientific and technical education, training, and research. Engineering schools will be particularly critical in our economic strategy, since engineering harnesses theoretical knowledge to create the products and processes of economic development.

Fifth, we need to build a capacity for retraining at all levels of our educational systems. Labor analysts and futurists alike agree that the average worker in the 21st century will have to retrain many times in his or her lifetime to keep pace with technological advances. We will need to expand programs to retrain and upgrade white collar and blue collar, skilled and unskilled laborers. Our institutions must adapt to the demand by making training and retraining accessible to older and part-time students. Industry, government, and the institutions themselves must support retraining programs and their students.

Finally, we must link higher education directly to economic development. North Carolina's customized training program for new and expanding industries, which makes the resources of the Community College system available to expanding employers, is already a national model for marshalling the resources of higher education for industrial development. Similar ties must be established between our senior institutions and industrial development efforts. We must also establish university-industry research and education programs so that advances of academic research will be translated quickly into practical application. In addition, our universities must manage patents arising from their research in ways that support academic principles and ensure efficient commercialization.

The members of the Committee on Research and Higher Education who developed this volume believe that its recommendations are the building blocks of a solid foundation for innovation. We invite all North Carolinians to work with us now in laying the groundwork for strong higher education that will support a prosperous North Carolina in years ahead.

The Committee wishes to thank Shannon St. John for her staff support.

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ACKNOWLEDGEMENTS

Task Force members wish to express their appreciation to the hundreds of persons who contributed to this study, particularly associate committee members, regional forum participants, and state government personnel.

The Task Force was staffed by four persons who contributed to all facets of Task Force activities and drafted the final report. Tom Rudin was the principal author of Volume I; Kirsten Nyrop, Volume II; Shannon St. John, Volume III; and Sanford Shugart, Volume IV.

Task Force members and staff are extremely grateful to Brenda Pennington, Gail Whitaker, Ann Cooper, Linda Cox, Beverly Horne, Paul Price, Cathy Peeler, Ron Ennis and Leon Neal, for their dedicated commitment and various contributions to the Task Force effort. Special appreciation is extended to Don Phillips, Director of the N.C. Biotechnology Center, for his assistance. A number of interns and fellows also had important roles in the work of the Task Force.

TITLES OF EACH VOLUME

Volume I - A Vision of Opportunity

Volume II - Economic Revitalization Through Technological Innovation

Volume III - Research and Higher Education: Building a Foundation for Education

Volume IV - Public Education and the Technological Challenge

Supplemental reports have been prepared by the Task Force's Committees on Agriculture and Forestry, N.C. and the World Community, and Science, Technology and Human Values.

All four volumes and copies of the supplemental reports can be obtained upon request from:

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RESEARCH AND HIGHER EDUCATION: BUILDING A FOUNDATION FOR INNOVATION

INTRODUCTION

Higher education has always occupied a valued place in the life of the people of North Carolina. Home of the first public university, the state has a long and proud tradition of respect for higher learning, and its colleges, universities and community colleges in turn have a sterling record of service to their communities.

Today the nation and the world are in the midst of a rapid technological transformation, and higher education must adapt to the challenges of a new technological frontier. To do this, higher education must become an integral part of the daily workings of every facet of North Carolina's economy and society. As technology requires both white and blue-collar workers to possess a high level of technical knowledge, higher education must stand ready to respond to the educational needs of the entire labor force. Research results, too, must be disseminated beyond the academic lecture hall into the workplace. And, of course, higher education must continue to educate students for life as well as work, teaching them to think critically and creatively, incorporating the wisdom of the humanities and social sciences into their decisions. Fulfilling higher education's many responsibilities will require educators to work with leaders in government and industry in regular, daily interaction. In short, in our technological age higher education must struggle alongside business, government, and individual citizens to improve the quality of life for all North Carolinians.

Chapter One outlines the present structure of higher education in North Carolina. The institutions of higher education vary significantly in their missions and governance structures, and the distinctions among them carry important implications for the recommendations presented in this report. A basic premise of this report is that improvements that are good for one group of institutions (e.g., higher quality faculty, more modern equipment, better-prepared students) are good for all. Nevertheless, some recommendations naturally address specific segments of the educational community: research institutions or technical institutes, for example. Furthermore, variations in the degree of state control over the public university system, the private colleges and universities, and the Community College System dictate that recommendations directed toward the public institutions can be more concrete and specific, whereas recommendations directed toward the private institutions must be more suggestive and general. Thus, although the Task Force strives for even treatment across all three sectors, the public sector receives particular emphasis where public actions are required.

Similarly, as the Governor's Task Force on Science and Technology, we have concentrated our examination on the scientific and technical fields. The intent is not to diminish the importance of the humanities and social sciences, for we find that philosophy, law, sociology, political science and other fields will be valuable contributors to decisions on man's use of technology in the years ahead. Nevertheless, a full examination across all disciplines of higher education was beyond the mandate of this Task Force. We urge all readers to examine the report of the Task Force's Committee on Human Values for a comprehensive discussion of philosophical and social concerns, not only as they relate to higher education but also as they discuss the wider issue of technological innovation.

In its work, the Task Force identified several broad concerns affecting higher education's ability to address the needs of the larger society. These issues most directly affect higher education's "outward" relationships in meeting such goals as economic development, more and better jobs, and an enhanced quality of life. They are set forth in Chapters Two and Three, and are underlying themes for the recommendations made in subsequent sections.

Yet even as a new set of demands requires academia to look outward toward the communities it serves, the institutions of higher education must also look inward. If the foundations of the educational system are not sound, then the system can fulfill neither its mission of service to the community nor its teaching and research functions. In approaching its mandate to examine the readiness of higher education to move into a technological age, the Task Force realized that it is the fundamentals of higher education -- students, faculty, and the new fundamental, information -- that will determine higher education's future strength and the quality of its contribution to the life of the state. The Task Force, therefore, has concentrated much of its effort in these three basic areas, foregoing more popular but less fundamental issues.

Within each category, the Task Force has identified areas of particular weakness for special attention. We do not intend to dwell on the negative, since we find much cause for optimism in the activities of North Carolina's centers of higher learning. Nevertheless, the Task Force felt bound by its charge from the Governor to concentrate its efforts on those concerns that pose the greatest threat to the soundness of higher education and thus to the state. Within each issue area the Task Force has specified key recommendations that it considers to be most essential to address the problems it has identified. This is not meant to devalue the other recommendations, but instead is an attempt to respond to the reality of resource scarcity by setting priorities. Appropriately, the recommendations are a mix of short-term changes and long-term initiatives. Both are equally important in a comprehensive strategy to strengthen research and higher education, but the long-term goals obviously will require dedicated effort over a longer period of time.

The Task Force has also discussed opportunities for the institutions to enhance their overall educational and research programs through revenue-generating activities that are consistent with higher educations' academic and public service missions. These activities -- Industrial-University Research and Assistance Plans, and Patent Management Arrangements -- are discussed in Chapter Seven.

The challenge of building the foundation for innovation, through strengthening research and higher education and channeling their resources toward meeting state needs, will require a consensus among the public sector, the private sector, and the academy. We hope that the ideas presented in this report will stimulate a dialogue among the three sectors and serve as a basis for concerted action.

Chapter One

OVERVIEW OF HIGHER EDUCATION IN NORTH CAROLINA

North Carolina's system of higher education today comprises three interdependent sectors: the Community College System, the University of North Carolina system, and the independent colleges and universities. Within and among the systems, the relationships are not rigid but dynamic, constantly evolving to accommodate students, communities, demographics, new technologies, and changing employment structures.

The primary mission of the Community College System is clearly stated in North Carolina law as follows: "The major purpose of each and every institution operating under the provisions of this Chapter shall be and shall continue to be the offering of vocational and technical education and training, and of basic, high school level, academic education needed in order to profit from vocational and technical education...." Of the 58 institutions that comprise the Community College System, 24 are community colleges offering college transfer programs that parallel the first two years of senior college curricula in addition to their vocational-technical programs. The remainder are technical colleges and institutes that do not offer traditional liberal arts college transfer programs. Some technical programs, however, are accepted for transfer to senior institutions under bilateral agreements.

Statewide, 12 percent of the full-time equivalent enrollment in curricular programs at community colleges are in college transfer programs. The remainder are in general education programs (4 percent), technical programs training for jobs as paraprofessional technicians (55 percent), and vocational programs training for entry into skilled occupational (29 percent). The Community College system practices a policy of open admissions, but with selective placement in specific programs according to the student's background and ability.

In 1979, the General Assembly established the State Board of Community Colleges as a separate governing board of the Community College System. The Board sets academic standards and guides the distribution of funds among the institutions. Individual institutions within the system are joint enterprises of the state and local governments: the state funds administration, instruction, and related equipment while the counties absorb the costs of buildings and plant operations. The state Department of Community Colleges provides guidance, coordination and assistance to the individual institutions under the direction of the Board.

The University of North Carolina, the state's public university system, has existed in its present form since 1971, when the Higher Education Reorganization Act defined "the University" to include the 16 public senior institutions. Governance was vested in a 32-member Board of Governors that subsequently delegated authority for personnel, admissions standards, degrees, student affairs and aid, and other matters to the Boards of Trustees of the individual institutions. The Board of Governors retains broad powers for control, supervision and management of the 16 institutions. The Board of

Governors also has authority to plan for "a coordinated system of higher education in North Carolina," but its role in planning for the private institutions and the institutions of the Community College System is consultative and advisory.

The University of North Carolina enrolls over 130,000 students, 84 percent at the undergraduate level, two percent in professional degree programs, and 14 percent in graduate programs. At the undergraduate level, 18 percent of the degrees awarded are in scientific and engineering fields; 36 percent of all doctoral degrees are in engineering and the sciences.

North Carolina is also the home of 38 regionally-accredited private colleges and universities. Each was founded originally by a religious denomination; the degree of denominational affiliation varies widely today. Seven are two-year institutions, and one is moving from two-year to four-year status. The 30 private senior institutions display remarkable diversity in structure and mission, and range in size from Barber-Scotia College (1982 enrollment: 374) to Duke University (1982 enrollment: 9,794).

Each private institution is chartered by the state and governed by an independent Board of Trustees. Collectively, the private colleges and universities are represented by the North Carolina Association of Independent Colleges and Universities. The programs of the private institutions are subject to the approval of their Governing Boards and to regional and discipline-wide accreditation standards. They must fulfill State licensing requirements to offer certain academic programs (e.g., nursing).

The senior institutions in the state vary widely in their academic programs and missions. One characterization of institutional functions is the Carnegie classification system, developed by the Carnegie Council on Policy Studies in Higher Education in 1976. A list grouping North Carolina's senior institutions by the Carnegie scheme is included as Table 1 on the following two pages. Each type of institution performs specific functions within the whole of higher education. For example, the research universities perform the greatest proportion of university basic research, and thus serve as a vital link between North Carolina and the world research community. The liberal arts colleges, on the other hand, are concerned primarily with undergraduate education. That each set of institutions plays a valuable role, and each is dependent upon the others, is a basic premise of the Task Force's work.

TABLE 1

CARNEGIE CLASSIFICATION OF SENIOR
INSTITUTIONS OF HIGHER EDUCATION IN NORTH CAROLINA

<table>
<tr><th colspan="2">Type of Institution</th></tr>
<tr><th>PUBLIC</th><th>PRIVATE</th></tr>
<tr><td colspan="2">1. Research Universities[1]</td></tr>
<tr><td>1. N.C. State Univ. at Raleigh</td><td>1. Duke University</td></tr>
<tr><td>2. UNC-Chapel Hill</td><td></td></tr>
<tr><td colspan="2">2. Doctoral Granting Universities[2]</td></tr>
<tr><td>1. UNC-Greensboro</td><td>(no comparable private institutions)</td></tr>
<tr><td colspan="2">3. Comprehensive Universities and Colleges[3]</td></tr>
<tr><td>1. Appalachian State Univ.</td><td>1. Atlantic Christian</td></tr>
<tr><td>2. East Carolina University</td><td>2. Campbell University</td></tr>
<tr><td>3. Elizabeth City State Univ.</td><td>3. Elon</td></tr>
<tr><td>4. Fayetteville State Univ.</td><td>4. Guilford</td></tr>
<tr><td>5. N.C. Agricultural and Technical State University</td><td>5. Johnson C. Smith Univ.
6. Mars Hill</td></tr>
<tr><td>6. N.C. Central University</td><td>7. St. Augustine's</td></tr>
<tr><td>7. Pembroke State University</td><td>8. Wake Forest University</td></tr>
<tr><td>8. UNC-Asheville</td><td></td></tr>
<tr><td>9. UNC-Charlotte</td><td></td></tr>
<tr><td>10. UNC-Wilmington</td><td></td></tr>
<tr><td>11 Western Carolina University</td><td></td></tr>
<tr><td>12. Winston-Salem State Univ.</td><td></td></tr>
<tr><td colspan="2">4. Liberal Arts Colleges[4]</td></tr>
<tr><td>(no comparable public institutions)</td><td>1. Barber-Scotia
2. Belmont Abbey
3. Bennett
4. Catawba
5. Davidson
6. Gardner-Webb</td></tr>
</table>

Table 1 (continued)

CARNEGIE CLASSIFICATION OF SENIOR INSTITUTIONS OF HIGHER EDUCATION IN NORTH CAROLINA

Type of Institution	
PUBLIC	PRIVATE
4. Liberal Arts Colleges (cont'd)	
	7. Greensboro
	8. High Point
	9. Lenoir Rhyne
	10. Livingstone
	11. Meredith
	12. Methodist
	13. N.C. Wesleyan
	14. Pfeiffer
	15. Queens
	16. Sacred Heart
	17. Salem
	18. St. Andrews
	19. Shaw University
	20. Warren Wilson
	21. Wingate
5. Schools of Art, Music, and Design	
1. N.C. School of the Arts	(No comparable private Institutions)

---

[1] Research Universities: Among the 100 leading institutions in federal funding and awarding at least 50 PhD degrees.

[2] Doctorate-granting Universities: Other universities awarding at least 50 PhD degrees.

[3] Comprehensive Universities and Colleges I: Institutions offering a liberal arts program in addition to professional or occupational programs, many offering the master's degree, but with very limited or entirely absent PhD programs.

[4] Liberal Arts Colleges: four-year colleges offering a liberal arts program.

Chapter Two

HIGHER EDUCATION AND THE NEEDS OF THE STATE

The basic premise of this report is that higher education must be internally sound, that the fundamental structure of its underlying academic programs must be healthy, before it can be expected to make a contribution to the larger needs of society. Nevertheless, higher education's ability to address state problems and opportunities is also dependent on the external links it establishes -- with business, with government, with other academic institutions. This chapter addresses the mechanisms needed to direct the resources of higher education toward meeting vital state needs, identifies stumbling blocks to higher education's contribution, and recommends steps to ensure that North Carolina will reap the full benefits of academic achievement in the years ahead.

Harnessing the Resources of Higher Education

The resources of higher education in North Carolina are at once abundant and scarce. Certainly, the creative potential of the human mind, at work in the classrooms and laboratories of North Carolina's institutions, knows no limitations. Yet higher education is also facing tremendous challenges to its resourcefulness. At the same time that slower growth in enrollments and in Federal support are forcing major adjustments, higher education is also being asked to take on a staggering array of new roles, including:

- training the technicians and skilled labor force needed to staff technology-intensive industries;
- educating the professional labor force, especially scientists and engineers, who will create and lead North Carolina's business enterprises;
- conducting research leading to new products and increased productivity; and
- assisting students and the public in understanding and adapting to technological change.

Meeting these new demands within the confines of limited resources will be the greatest challenge to higher education in the next two decades. It will require a concerted effort on the part of government, industry and the institutions themselves. It will require directing and guiding the resources of higher education toward specific state priorities such as economic development. Most of all, it will require new channels of communication among business, government and academe, and among the academic institutions themselves, to agree upon common goals and the steps necessary to achieve them.

In many ways, North Carolina is already a model of inter-institutional and inter-sectoral communications and cooperative efforts. Within higher education, the Triangle Universities Computation Center (TUCC) provides information processing facilities and services for Duke University, the University of North Carolina at Chapel Hill, North Carolina State University, the Research Triangle Institute, and other North Carolina educational institutions. Several research institutes, such as the Triangle Universities Nuclear Laboratory and the Triangle Semiconductor Research Center, tie together the state's three research universities for extending knowledge in specific fields. The Triangle Universities Center for Advanced Studies serves as a directorate and site for inter-institutional graduate programs such as the Microelectronics Center and the National Humanities Center. Other programs, such as the Sea Grant College program, bring together the resources of several public institutions for research on matters of regional, state, and national importance.

The state's recognition of the importance of university-industry-government links is evidenced by its establishment of the Board of Science and Technology. The Board functions as a "nerve center," assuming a central role in strengthening the state's science and technology base. Its 15 members, drawn from public and private universities, private industry, and state and local government, develop important policy recommendations and programs in such areas as public understanding of science, science and mathematics education in the schools, university research, and new technology development. Institutions such as the Microelectronics Center and Biotechnology Center, both spawned in part through the efforts of the Board of Science and Technology, focus university-industry linkages toward specific technological opportunities for North Carolina.

In spite of these many cooperative efforts, North Carolina is being pushed and challenged by other states to devise mechanisms to strengthen still further the ties among industry, campus, and government, and between academic institutions. The State of Pennsylvania, for example, committed $1 million to create four Advanced Technology Centers to conduct joint R&D, education, and training. The Centers are consortia of educational institutions, business, financial institutions and local development districts, and state funds must be matched from private sources. The state now is allocating $10 million for implementation of the four centers. In Michigan, a state devastated by unemployment in its basic industries, the state government has committed millions of dollars to build a series of generic technology institutes in robotics, biotechnology, and other promising technologies. The Industrial Technology Institute, for example, has received funding of more than $100 million from the state and private industry, and will bring together about ten Michigan universities with programs in robotics and automated manufacturing.

In subsequent sections of this report, the Task Force on Science and Technology makes recommendations that address some specific linkages. We propose, for example, that an individual be located in the Department of Commerce for liaison with colleges and universities in industrial development, and that a state-funded research program to focus university research on specific state needs be created. The Task Force, however, has neither the time, the expertise, nor the mandate to determine the systemic changes needed to keep higher education responsive to state needs in a technological age.

Nevertheless, the issue of the proper mechanisms needed to harness the resources of higher education to meet critical state needs is of such overriding importance as to warrant special examination.

Although the Panel we recommend necessarily will address institutions and institutional systems, its purpose is not to focus on the structure of higher education in North Carolina, but to find ways to capitalize on the resources we have. The independent examination we recommend will not, and is not intended to, undermine institutional authority, but rather to provide another perspective on higher education's potential contributions to the state. The Task Force believes that full and open deliberation of fundamental issues can only strengthen higher education in North Carolina. For that reason, we applaud the work of other independent bodies, such as the prospective study of higher education by the Z. Smith Reynolds Foundation, as well as the periodic self-studies by the Board of Governors, the Board of Community Colleges, and individual institutions, for their contributions to the discussion.

The Task Force recommends:

o Blue Ribbon Panel on Higher Education and State Needs

A blue-ribbon panel should be created to determine how best to harness the resources of higher education to meet vital state needs. The panel should consist of the President of the University of North Carolina, the President of the North Carolina Association of Independent Colleges and Universities, the State President of the Community College System, other representatives of higher education, representatives of elementary and secondary education, the Secretary of Commerce and other key members of state government, representatives of the General Assembly, and a significant number of industry representatives and members of the general public. The panel would be charged with devising mechanisms to:

- install a capacity for coordinated response to State needs among North Carolina's institutions of higher education.
- strengthen the ties among industry, government, and higher education for identifying and addressing state problems and opportunities.

Specifically, the Panel should be responsible for recommending what policy, procedural, and organizational changes should be made to ensure higher education's responsiveness to state needs, and for developing an action plan to implement their recommendations. Providing the Panel with staff and other essential resources will cost about $40,000.

State Government and Higher Education

Channelling higher education toward the public goals of the state will require a much closer working relationship between state government and the institutions of higher education. The Task Force has identified two particular areas for closer cooperation: industrial development, and the budgeting and appropriations process.

Partnership in Industrial Development. High-technology manufacturers and advanced service industries are footloose establishments. Freed from the need for geographic proximity to raw materials and markets, most weigh the quality of the labor force as the most important factor in their locational decisions. North Carolina has explicitly recognized this relationship in the linkage it has established between the Industrial Development Division of the Department of Commerce and the Community College System. But high-technology firms are also concerned with the quality of the professional labor force, and with the educational, cultural, and research base provided by the senior colleges and universities, necessitating a strong role for the senior institutions in industrial development.

In the Community College System, the Training Program for New and Expanding Industries ensures a close working partnership with the Department of Commerce's industrial development operation. Most initial contacts are handled by the central office of the Department of Community Colleges. Representatives of the new and expanding industries program explain to new firms the resources of the Community College System, its vocational-technical programs, and the new and expanding industries program. The customized training program is managed by community college personnel located in each of seven Commerce Department regional offices. They work with new and expanding firms to learn their specific training needs, and then work with the institutions to tailor training programs for the new companies. Although the regional office personnel may not always be involved directly in the recruiting process, they serve as another link between the industrial developers and the community colleges.

Such an elaborate structure is probably neither practical nor desirable for the senior institutions. Nevertheless, the present practice of involving the senior institutions in industrial recruiting on an *ad hoc* basis, often at the last minute, does not allow the state to present its best image. Particularly since industrial developers report a marked increase in the number of firms inquiring about the professional labor force, a closer partnership between the state's colleges and universities and its industrial recruiting apparatus is needed. The Task Force believes that regular interaction will enable the institutions to prepare in advance for the kind of questions and needs new firms express, and greatly strengthen the state's overall recruiting posture.

Therefore, the Task Force recommends:

- College and University Liaison

  The Department of Commerce and the state's senior institutions should develop an active partnership in the industrial recruiting process. The central focus of the partnership would be an individual, located within the division of the Department of Commerce responsible for high-technology development, who would be responsible for liaison with public and private senior institutions on both an ongoing and project-specific basis. Salary and other support services are expected to cost about $71,000 per year.

Budgeting and Appropriations. The legislative and executive branches of North Carolina exercise their oversight responsibility for public higher education in the state through the budgeting and appropriations process. They exercise management review by examining previous expenditures and authorizing new ones. They signal new areas of interest and priorities by shifts in program funding. As a result, budgeting is far more than an administrative process, and strikes at the very core of the operation of higher education in North Carolina.

The Task Force affirms the responsibility of oversight from the state's legislative and executive branches, but has identified two problems with the present budgeting process that threaten the effectiveness of North Carolina's public higher education. The first concerns managerial flexibility within budgeted and appropriated categories of expenditure, and the second concerns budgeting for cost differentials among different types of academic programs.

The twofold purpose of the budgeting and appropriations process at the state level is to ensure accountability of allocated funds and to keep total expenditures within the limit of total revenues as required by the state Constitution. The Task Force recognizes the importance of these goals, but finds that within the systems of public higher education, the existing procedure unduly constrains the managerial autonomy and responsiveness of the institutions.

At present, the State Budget Office prescribes that the UNC institutions (and all other agencies of state government) submit their continuation budget requests in a format of narrow, detailed line items (e.g., educational supplies, repair supplies, office supplies) rather than broad categories (e.g., supplies). The line item budgets are further categorized by "purpose codes": regular term instruction, summer term instruction, extension instruction, academic support, student services, etc. The budget submitted by the Governor to the General Assembly follows the same format, and not surprisingly, appropriations are made by the General Assembly at the same level of detail.

Until this year, university administrators had to seek permission of the State Budget Office to shift any funds, regardless of how small the amount, from any line item to another. The result was an administrative nightmare, since administrators found it inherently impossible to predict expenditures perfectly 18-30 months in advance (when the budgets are prepared). Recently, the Budget Office has taken steps to increase the flexibility afforded to administrators, who can now shift funds among like kinds of expenditures (e.g., all types of supplies). The recent action is a giant step in the right direction, and the Task Force applauds the Budget Office's efforts. Nevertheless, some steps remain to be taken to give university administrators the managerial autonomy that will best serve the interests of North Carolina.

First, administrators are still unable to shift resources across "purpose codes." This means, for example, that if a professor is needed to teach during a summer session, rather than the regular academic year as was anticipated at the time the budget was prepared, approval to transfer the funds must be granted by the State Budget Office. If the approval is not forthcoming, the now un-needed salary funds in the regular term budget "revert" to the state General Fund and are lost to the use of higher education altogether for that fiscal year.

Besides creating administrative headaches, the overload of detail and paperwork circumvents the original purpose: managerial control. At the institutional level, the narrow line items discourage savings, since they encourage departments and institutions to spend at historical levels rather than seeking to conserve resources. Moreover, the system makes cost-effective management difficult, if not impossible, because the administrators often cannot shift resources to take advantage of opportunities for savings. Finally, the line items bear little relation to the program units of colleges and universities, so the budgeting system is of negligible value to them as a managerial tool.

Aggregating budgets and appropriations into broader categories (e.g., all salaries, all supplies) and allowing transfers across purpose codes would enable university administrators to exercise effective management control of expenses. It would allow the State Budget Office and the General Assembly to execute more realistically their oversight responsibility for UNC system expenditures by focusing on major categories of expenditure. Finally, it would eliminate the unnecessary administrative costs of the present system.

An important point is that this reform would be accomplished without any loss of accountability to the public. Expenditures could still be reported to the Budget Office and General Assembly in the existing line item format. Other states have adopted this approach, based on post-expenditure accountability rather than pre-expenditure control, and find that it works effectively and efficiently in their public universities.

These are not narrow administrative issues. The quality of higher education can be only as good as the quality of its management, and management is fundamentally dependent on the management and budgeting system. The current budgeting process is handicapping both the quality and cost-effectiveness of the University of North Carolina system. If the state's public university system is to maintain its standard of excellence, then its administrators must be given the flexibility to manage their programs in an effective and efficient manner.

Therefore, the Task Force recommends:

- Increased Flexibility in Budgeting and Appropriations

  The State Budget Office and the General Assembly should work together to provide academic administrators with the flexibility needed to manage college and university programs more efficiently, by budgeting and making appropriations in broader categories and/or allowing transfer of funds, without prior approval, among more categories of expenditure.

The Task Force's second major concern is the manner by which funds are allocated among the institutions of higher education. In North Carolina, budgeting for public higher education across the board is driven by one magic number -- the full-time equivalent student enrollment, or FTE. The full time equivalent enrollment aggregates part-time students on the basis of their course-hour enrollment; for example, two half-time students would count as one full-time equivalent. Basic allocations to individual institutions, in both the Community College System and the University of North Carolina, are based on the number of full-time equivalent students enrolled.

On the surface, this might seem a reasonable and equitable way to distribute scarce resources. But it fails to take into account the higher costs of technical programs and courses. Scientific and technical courses are costly for several reasons. First, they are equipment-intensive, requiring complex and expensive tools for teaching and research. Second, salaries for faculty members and instructors in those fields have been bid up by competition with private industry for highly-trained scientists, engineers, and technicians. Finally, the nature of the course material dictates that much instruction be conducted in small classes and laboratories, necessitating a low student-faculty ratio.

The present budgeting systems are not responsive to the higher costs of scientific and technical programs. Under the current allocation scheme, for example, a community college would receive as much funding for a student enrolled in a cosmetology program as for an electronics technician. Similarly, in the UNC system the basic distribution of resources will be based on the same allotments per FTE student for a comprehensive university with an engineering school as for one without a costly technical program.

The failure to distinguish between the more costly technical programs and other programs in budget formulas has forced institutional administrators to engage in numerous forms of robbing Peter to pay Paul. In the community colleges and technical institutes, the formula provides incentives for administrators to increase enrollments in their low-cost courses in order to subsidize their higher-cost courses. Ultimately this could lead to a distorted course mix that does not reflect North Carolina's emphasis on high-technology occupations. Similarly, meeting the salary requirements of engineering faculty in a UNC institution means there is less to distribute among the institution's arts and sciences faculty -- a problem that counterpart institutions without expensive technical programs do not face.

The present budgeting system is hindering the development of essential but costly scientific and technical programs in the Community College System and the UNC system and is inconsistent with North Carolina's objective of technological development. Several alternative funding methods that recognize cost differentials include:

- initiating funding formulas based directly on program costs
- adding a lump subsidy to the base amount per FTE for institutions with a high proportion of technical programs
- retaining the present FTE formula and relying upon special legislative appropriations for science and technology programs

The Task Force does not presume to dictate a new funding mechanism, but believes that the present problem needs immediate attention and resolution. Therefore, we recommend:

- Budgeting to Recognize Cost Differentials

  The General Assembly, Department of Community Colleges, and the Board of Governors should recognize the higher costs of scientific and technical programs in their budgeting processes, and allocate resources among institutions accordingly.

Engineering Excellence

Engineering schools stand at the juncture of higher education and economic development. Engineering links theoretical knowledge to the practical pursuits of society. It is no accident that the hotbeds of high technology growth in this nation are located adjacent to the country's finest engineering schools.

As North Carolina moves toward a more technology-intensive economy, it will need to recruit advanced-technology firms from out-of-state and to create new firms from new technologies within the state. This point is made eloquently in the Volume II, but is important to higher education because truly superior engineering schools will be necessary for both. High-technology firms seek out locales with strong engineering programs to meet their engineering manpower needs and to provide continuing education for their engineering personnel. They also look for engineering research that will generate new ideas, products, and processes for their enterprises and keep them competitive. Furthermore, in other states superior engineering schools have spawned many of the spinoffs that are today's high-technology giants; for example, Hewlett-Packard (spun off from Stanford) and Wang (spun off from MIT).

One year ago, the University of North Carolina hired a trio of outstanding engineers to evaluate North Carolina's public engineering program and develop a strategy for upgrading engineering education in the state. The Task Force agrees with the basic tenet of their report, entitled "Engineering Education in the University of North Carolina":

> "For North Carolina, current goals of industrial development, particularly in various areas of high technology, depend to a large extent upon the level and quality of engineering education..."

The conclusions of the consultant's study are largely incorporated into "Long-Range Planning 1982-87," published by the Board of Governors in 1983.

The Task Force has concluded that two ingredients are absolutely essential if the state is to reach its full potential in economic growth through technology. First, North Carolina must have strong, solid programs in all of its schools of engineering, public and private. Second, to attract and foster new innovative businesses, the state must have at least one engineering research institution of national stature. The Task Force believes that the strong base now existing at North Carolina State University's School of Engineering justifies a dedicated effort to help it achieve engineering research preeminence.

Experience in other locales demonstrates that, to capitalize fully on the opportunities of technology, North Carolina must draw upon the resources of both public and private institutions. Duke University's fine engineering program is an invaluable asset to the state, and occupies an essential niche in the constellation of engineering schools that comprise a comprehensive system of engineering education in North Carolina. The people of North Carolina should encourage its development and growth, and the University of North Carolina should should seek opportunities for coordinated and cooperative efforts with Duke's engineering school. The Microelectronics Center of North Carolina is an outstanding example of collaborative activity among public and private institutions in technology.

That the recommendations in this section address primarily the public engineering schools, then, is not a negative reflection on the contribution of the private engineering program at Duke to the state. It is, instead, a recognition that the State has greater influence on the development of public higher education than private education. Because the Task Force recommends specific strategies to be adopted by the UNC engineering schools, imposing a similar level of detail on the private sector of higher education would be presumptuous and inappropriate. Nevertheless, we commend the strategies outlined to the private engineering school for its consideration, and urge that it adopt these recommendations where they are consistent with its plans and goals.

To upgrade engineering education, the State will have to commit substantial resources to the engineering schools. In the short term, this may mean reallocating funds away from other state or university activities, but in the long term the payback in economic development and jobs will more than justify the investment. Several of the recommendations contained elsewhere in this report will support the goal of strengthening engineering education. In Chapter Five we recommend special appropriations for scientific and technical faculty members, expanding engineering and computer science facilities, and increasing technical support staff. Instituting a budgeting system that recognizes the higher costs of technical programs, as suggested earlier in this chapter, would contribute immensely to improving the public engineering schools. In addition, the State will need to develop specific strategies for building engineering programs. The Task Force recommends:

o Establishing Strong Engineering Schools

  North Carolina should invest about $1.5 million above present levels annually to establish strong, solid programs in all of its engineering schools.

  Among the specific strategies that can be used to achieve this goal are:

  - Build programs by hiring a few truly distinguished professors

    A few outstanding senior professors will attract talented young faculty and excellent students, the core of any academic program. During the 1983 legislative session, the engineering schools at UNC-Charlotte and NC A&T State University received special funding for faculty research positions. This should be continued to allow the schools to build their faculties.

- Concentrate resources to establish a few outstanding departments

  In conjunction with hiring outstanding faculty members, the engineering schools that are not major research institutions should assess their strengths and the particular needs of their regions of the state and concentrate their resources to create a few outstanding departments. UNC-Charlotte, for example, has targeted manufacturing-related engineering as a major emphasis because of the huge base of traditional manufacturers in the Charlotte area. UNC-Charlotte and N.C. A&T State University should take advantage of their association with the Microelectronics Center to extend their on-campus capabilities.

- Service to industry

  The comprehensive institutions have a particular responsibility for fulfilling the needs of local and regional businesses. They already do so by training engineering manpower for North Carolina industries, but can also build their programs by providing technical assistance and conducting research for industrial sponsors. Establishing Industrial-University Research and Assistance Plans, as recommended in Chapter Seven would provide a mechanism for this type of service to industry while contributing to educational programs. A corollary of this activity is that it is appropriate for engineering faculty to be involved in mission-oriented applied research, and that the importance of this kind of work should be reflected in promotion and tenure decisions.

- Build up complementary departments

  Engineering education cannot exist in a vacuum, but must be supported by strong departments in the physical sciences and mathematics, particularly at the undergraduate level. UNC-Charlotte has already recognized this principle by devoting $8.9 million to build a new Physics and Chemistry building which will serve engineering students along with other students. All the engineering institutions should take care to strengthen their chemistry, physics, and mathematics departments as they improve their engineering programs.

- Create separate tracks for marginal students

  The undergraduate engineering programs at UNC-Charlotte and NC A&T State University have a special responsibility for fulfilling the strong demand of North Carolina's industries for engineers and for bringing disadvantaged students into the engineering profession. But they cannot afford to carry students who, because of poor educational preparation, must continually repeat courses and drain scarce resources. One solution to this dilemma is to create special tracks that would provide selected remedial assistance and tutoring for marginal underclassmen. An example is the "pre-engineering" program recently begun at UNC-Charlotte. This type of program gives marginal students a chance but also limits the university's financial commitment: if a student is unable to perform satisfactorily in spite of extra assistance, he or she will be dropped from the engineering curriculum. North Carolina A&T State's new matriculation policy serves a similar purpose. Special funding, outside the normal teaching allotment, might be appropriate for these programs.

o Develop a Nationally Superior Engineering School at North Carolina State University

North Carolina should commit an additional $9 million in facilities over the next four years and $2.5 to $3.5 million annually for other investments to build upon the strong base now existing at North Carolina State University to create a truly outstanding school of engineering with a national research reputation. All of the engineering schools will benefit from having a premier engineering research school in the state, and all the schools should cooperate to ensure that they are able to take full advantage of N.C. State's programs. The programs of other engineering schools should complement those at N.C. State, thereby providing the state with a comprehensive system of engineering research and education.

Specific strategies that may be pursued to achieve the goal outlined above are:

- Retain and develop outstanding young faculty members

  One-third of the faculty at NC State's engineering school have been recruited in the last 5 years, and many of them are potentially outstanding researchers. To retain them, N.C. State must be able to offer them adequate compensation; the special appropriations for faculty salaries recommended in Chapter Five would be particularly helpful. In addition, teaching loads must be kept at a reasonable level to allow these young faculty members time to explore innovative research ideas. N.C. State should follow the lead of other outstanding engineering schools and hold undergraduate enrollments at or below current levels. This is a particularly reasonable strategy in North Carolina since the state boasts three public engineering schools.

- Build programs by hiring a few outstanding senior professors

  Like the comprehensive institutions, North Carolina State can strengthen key departments by hiring a few distinguished senior professors who will in turn attract outstanding younger colleagues and graduate students. In a research university, hiring senior professors can be a major commitment since it requires funds for equipping labs and supporting graduate students as well as salaries, and total price tags can easily run $200,000 to $400,000. Nevertheless, it is one of the most successful strategies for establishing a national research reputation. During the 1983 legislative session, the N.C. State School of Engineering received appropriations for two senior research positions. A similar commitment for two or three more positions during the next legislative session would greatly enhance N.C. State's ability to recruit top researchers from across the country.

- Concentrate resources to establish a few outstanding departments

North Carolina State University should assess its strengths and the needs of the state and select three or four programs or fields for special support. Candidate fields might include:

o Manufacturing engineering
o Construction engineering
o Precision metals engineering
o Communications and signals processing
o Microelectronics
o Biotechnology engineering

- Capitalize on the other resources of the university

Some outstanding engineering schools, Georgia Tech and Rensselaer Polytechnic Institute, for example, are located in universities where the engineering departments dominate the campus, and only a minority of students are not in the engineering curricula. North Carolina State is a much more diversified university, which poses some difficulties for its engineering school in trying to establish itself among the premier technical institutions. Nevertheless, the engineering school can take advantage of the University's other offerings to distinguish its programs. Particularly, N.C. State's engineering students have access to an outstanding business and economics department, which can equip them for managerial as well as technical positions. The engineering school should capitalize on the business and economics offerings to the maximum extent possible to educate engineer/managers and engineer/entrepreneurs.

- Aggressively pursue industry-sponsored research

The two largest sources of research support in engineering are the federal government (primarily the Defense Department) and private industry. The defense contracting networks are already well-established and often require huge initial capital investments. Industrial commitments, on the other hand, are much less rigid and carry the added bonus of building private support for the institution. North Carolina State's engineering school already has a solid base of industrially-sponsored research -- $2 million in the 1981-82 school year. Establishing an identifiable organization for conducting industrial research, such as the Industrial Research and Assistance Plan suggested in Chapter Seven, would provide greater visibility for the engineering school's industrial research and generate additional revenues for teaching programs. Returning a portion of negotiated overhead to the Principal Investigator, as recommended in Chapter Two, would also provide incentives for faculty to pursue research opportunities more aggressively.

- Launch an aggressive development campaign for the engineering school

The development campaign at the Georgia Institute of Technology last year netted $12.5 million for research and research equipment. Forty percent of alumni contributed. Although those revenues amounted to less than one-tenth of the school's total receipts, they provided a critical margin of flexible dollars outside the restrictions of state appropriations and Federal and private research contracts. It is the development campaign that allows them to pursue new avenues of research and teaching. Flexible resources will be critically important to N.C. State's engineering school as it strives to establish programs of national stature, so an aggressive development campaign should be mounted as quickly as possible.

- Recruit excellent out-of-state students

National reputations are established through active academic interchange with institutions throughout the country. Students are an important component of academic interaction; as they move from institution to institution, they spread impressions of programs from one academic community to another. If N.C. State's engineering school is to establish a national reputation, then it must be able to attract students from outside North Carolina to spread the word across the country. Chapter Four of this report discusses the importance of graduate students and ways to recruit the most outstanding, including fellowship support and waiving out-of-state tuition. Undergraduates also have a role to play, particularly in engineering, which offers a professional degree at the undergraduate level. At N.C. State's engineering school, out-of-state undergraduate admissions have been held to about 15 percent. At Georgia Tech, another public engineering school, out-of-state students make up 40 percent of undergraduate population, and as they have entered graduate programs and employment throughout the nation, they have been a key ingredient in Georgia Tech's rising reputation. Restrictions on out-of-state undergraduates should be loosened at N.C. State's engineering school, and an aggressive campaign initiated to recruit the finest out-of-state students at both the undergraduate and graduate levels.

Chapter Three

STRENGTHENING RESEARCH IN NORTH CAROLINA

Research is the foundation of the educational enterprise. Through research, the frontiers of knowledge are constantly being pushed into new realms. Research refines and augments the body of knowledge being transmitted to students in the educational process. But, increasingly in recent decades, research has also become an underpinning of economic growth, of national defense and of space exploration.

Research Strategy

In stressing needs of the state in the previous chapter, considerable emphasis has been placed upon engineering. This appears to be the current overriding need, given the concern of the Task Force with economic revitalization through technological innovation. Nevertheless, much attention needs to be given to other fields of science and mathematics as well, especially when the structure of higher education is cast against the background of strategicallly important needs of research as well as education.

Sufficient resources and time were not available to the Task Force to permit a comprehensive development of research strategy for this state. In this and subsequent chapters of this volume, however, many recommendations are put forward that are designed to improve faculty, facilities and student selection and preparation in all fields of science, engineering and mathematics. In this chapter, in particular, reference is made to the need for a research strategy consistent with economic revitalization, provision of jobs and other goals and objectives.

Not all research would be guided by such strategy. The intent would be to complement, or offset where appropriate, the influence of federal and private strategies.

National and International Influence

Strengthening research in higher education, and in other institutions and agencies in North Carolina, must be first considered within national and international contexts. Also, because basic research, applied research and development are intertwined, the conventional term research and development (R&D) should be used.[1]

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[1] The concept of R&D used in this section is that developed by the American Association for the Advancement of Science in cataloging R&D expenditures in the United States. It is somewhat more "directed" or "mission oriented" than would be a full measure of all university expenditures on R&D. Some institutions do not differentiate clearly between teaching and research expenditures for faculties, buildings and equipment. For more detailed information, see AAAS Report VIII: Research and Development, FY 1984, and previous annual volumes (American Association for the Advancement of Science: Washington, 1983).

In round numbers, current expenditure for R&D in the U.S. in 1983 is expected to total $86 billion. Of this total, the federal government will provide nearly $40 billion, private industry more than $40 billion, colleges and universities from their own sources less than $2 billion, nonpublic institutions nearly $4 billion, and state governments probably somewhat less than $1 billion.

Of the $40 billion R&D expenditure by the federal government, about $25 billion, or more than half, will flow through the Department of Defense. The remaining $15 billion is spent by other federal agencies and departments.

In constant 1972 dollars, federal expenditures for R&D now stand at about the same level as in 1967 ($18 billion). Industrial expenditures, however, have doubled, rising from $10 billion to $20 billion.

Industry now *performs* about 74 percent of all R&D, even though it *funds* only 51 percent. The federal government *performs* only 11 percent of all R&D, even though it *funds* nearly 46 percent. Universities *perform* about 9 percent of all U.S. R&D, and fund from their own sources less than 2 percent of the U.S. total. But of this 9 percent of all U.S. R&D that universities execute, the federal government *funds* nearly 67 percent, and industry a little less than 5 percent.

It is important to note that universities perform about 57 percent of all basic R&D conducted in the U.S. Industry, by contrast, performs about 19 percent of all our basic research. Industry concentrates its attention on applied research and development. Of all the R&D that industry performs, about 3 percent is for basic research, 20 percent for applied research and 76 percent for development. With colleges and universities the situation is reversed: 67 percent is basic, 27 percent applied and 5 percent development.

Thus, it seems clear that the federal government dominates the funding of R&D, and that the lion's share of federal support flows through DOD, heavily influenced by international relationships. Industry concentrates its expenditures upon applied research and development, and is funding nearly 5 percent of the total R&D conducted by universities. Industrial policy, especially that of the multinational firms, is also influenced significantly by international competitive conditions. Universities, of course, have dominated the basic research field in the U.S.; they have been less involved in applied research, and even less in development pursuits.

It should be noted also that university R&D in the U.S. is conducted primarily by the 184 Ph.D.-granting research universities, 119 of which are public institutions with most, perhaps all, receiving support from state governments.

The Changing State Government Role

Compared with federal and private expenditures for R&D, outlays by all 50 state governments of about $1 billion per year seem almost insignificant. But as a recent report of the Task Force on Technological Innovation of the

National Governors' Association reveals, this situation is changing.[1] The 1981 AAAS report on R&D estimates that, in 1977, total state support for R&D was about $350 million. No recent total appears complete, but the NGA study clearly indicates that states are pursuing many R&D initiatives in relation to programs designed to create more and better jobs through technological innovation.

To give explicit examples, California and Massachusetts represent states in which private sector development, stimulated by federal R&D expenditures dating back to World War II, has resulted in innovative industrial growth areas now identified as "Silicon Valley" near Stanford University and "Route 128" near Harvard and MIT. Only in recent years has state government, in each case, taken action to build on and broaden these early developments by creating special organizations. Examples are the Massachusetts Technology Development Corporation (1978), and the California Commission on Industrial Innovation (1981). Each state is taking several other government initiatives, but these organizations illustrate the point.

Still other states have evolved different strategies. Connecticut, with its Connecticut Product Development Corporation (1973), was one of the early states to foster innovative development. Current funding of CPDC totals $10 million. Michigan, with a traditionally strong industrial base, particularly in automobiles, was by contrast a latecomer in assuming the forms of leadership that North Carolina and other states are pursuing. Stimulated by severe unemployment, especially in the automobile industry, the Michigan High Technology Task Force was established in 1981 for the purpose of enabling Michigan to become a world leader in robotics, molecular biology and related fields. Soon thereafter, the Industrial Technology Institute, with public and private funds of more than $100 million, was formed to help existing Michigan manufacturers, particularly automobile firms, remain competitive by a adopting new forms of computer based production and to take other steps to help create jobs by stimulating economic growth. Michigan also established the Molecular Biology Institute in 1983, with a commitment of $6 million per year for 10 years from public and private sources. Other steps are being taken by still other states, all of which seek to blend advances on the frontier of science and engineering with existing institutional resources and with other pursuits.

A few states continue to place emphasis upon industrial recruiting and worker training, with only indirect action to utilize scientific and engineering resources to stimulate growth. These states represent the less intense end of a range that extends to those states with the most vigorous and comprehensive programs. All states appear to be at various points on that range, depending upon the state organization and strategy.

The NGA report indicates that, for the most part, state organization and strategy concentrates upon the deliberate, systematic use of scientific, engineering and technological resources through a partnership of government, academia, industry and people. It deliberately foreshortens the time span between basic research advances and utilization of such concepts in improving the health of people; in improving education; in developing trade and other international relationships; in reconstructing roads, bridges, water and sewer systems and other elements of the infrastructure we have allowed to deteriorate seriously in the United States; and in participating in the creation, domestically and internationally, of a new, complex structure of production, trade and commerce within states, among states and with other nations. All these, of course, create new job opportunities for citizens.

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[1] See Technology and Growth: State Initiatives in Technological Innovation, including the appendix (National Governors' Association: Task Force on Technological Innovation, Washington, 1983).

A state level task force, board or commission must be created by the Governor, as has been done in North Carolina, to foster development and implementation of innovation policies and programs. The organization works with components of the partnership throughout the state in outlining specific needs and opportunities. It concentrates upon both public and private sector activities and it formulates short- and long-run objectives. The style of leadership is catalytic and supportive, rather than administrative and regulatory.

Comprehensive state programs seek to fill voids that exist in institutional structures. For example, it is difficult for new small business firms to get started, and for existing small business to expand, drawing directly upon innovative ideas flowing from scientific and engineering research. As a consequence, innovative development organizations, incubator facilities and venture capital firms are being established in several states to assist new small business ventures get off the ground.

Working relationships between universities and industries are being enhanced throughout the U.S. by the establishment of microelectronics and biotechnology centers, research affiliates programs and other industry-university linkages. New and/or advanced technology is pursued rather than simply high technology. This ensures that traditional industries such as textiles and automobiles are encompassed, as well as new firms concerned with computers, robots and other highly sophisticated technology. Training and retraining of workers are given high priority, and special arrangements between community colleges and industrial firms are devised to match qualifications with requirements. Advanced education and research programs in universities are strengthened.

Recognizing that, in the long-run, no individual will be able to function effectively in modern society without rigorous education at elementary and secondary levels, the comprehensive approach places great emphasis upon state leadership in assisting local communities as they take steps to improve their schools, particularly improvement in science and mathematics.

Thus, it is clear that research and development--the complex process ranging from basic research pursuits to the innovative use of research results in achieving particular purposes of society--is becoming a central element of state policy, especially in North Carolina and other leading states. R&D is of critical importance in achieving economic revitalization through technological innovation, as set forth in Volume II of this Task Force Report. R&D is essential to the environmental programs of state agencies, local governments and the private sector, including effective management of toxic and hazardous substances in waste and other forms. R&D is vital to both public and private aspects of health care and other social services, particularly in North Carolina since the state has four medical schools, a school of public health and other research and education resources fully capable of exercising creative leadership in providing effective, efficient and equitable services. R&D is also essential to the development of innovative ways by which states reconstruct and/or expand bridges, water and sewer systems and other elements of their infrastructure.

Research in North Carolina Institutions

Partnership relations among state government, research institutions and the private sector, in the form now pursued by states, may be traced in North Carolina to the creation of the Research Triangle Park in the 1950s. Nearly 50 federal, state and private R&D facilities have located there since 1958 (IBM, Research Triangle Institute, National Institute of Environmental Health Sciences, etc.). More than 20,000 people now work in this Park each day and the total payroll amounts to approximately $500 million per year. The Park is the centerpiece for North Carolina industrial recruiting practices, resulting, in recent years, in new industrial investment approaching $2 billion per year.

Whereas, for the nation, most university research is conducted by research universities, in North Carolina the base is broader. Duke University, the University of North Carolina at Chapel Hill, and North Carolina State University are research universities and, of course, make up the symbolic points of the Research Triangle, within the center of which is the 5,000 acre Research Triangle Park. In fiscal year 1980, Duke ranked 23rd among the nation's universities in the amount of total federal research funding ($42.5 million) and UNC-Chapel Hill ranked 25th ($41.8 million). North Carolina State University ranked 77th, but ranked 40th in total expenditures for research and development. The 16 constituent institutions of the UNC System performed $108.8 million in sponsored research in FY82. Of that total, UNC-Chapel Hill (including the Medical Center) accounted for $59.8 million and North Carolina State University for $24.5 million. In addition, the Research Triangle Institute, the contract research institution in the Park owned by the Triangle Universities, conducted research totaling $41.4 million in 1982.

Research conducted in the state's four-year colleges and comprehensive universities also benefits the state and its institutions. Through academic research, faculty members at these institutions expand their professional knowledge base and maintain the vitality of their teaching. In addition, research conducted at four-year colleges and comprehensive universities often addresses specific local or regional concerns that would not be explored at major research universities. In the UNC System, the institutions that are not major research universities conducted $24.5 million in research in 1982.

Approximately 7.5 percent of research funding in the UNC System is provided by the State of North Carolina, as compared with 78.5 percent from federal sources and 14 percent from other sources. Across the UNC institutions, sponsored research increased about one percent between FY81 and FY82. Department of Defense sponsored research increased by 64 percent, but overall federal research funding declined 2 percent, reflecting overall changes in the federal budget.

Recognizing the need to keep better account of R&D expenditures in North Carolina, the Board of Science and Technology began assembling budgetary data of this nature in 1980. The system is by no means sufficiently developed nor adequately comprehensive; much more needs to be done. Table 1, however, reflects the trend in expenditures to some degree.

TABLE 1

NORTH CAROLINA STATE GOVERNMENT SUPPORT FOR RESEARCH & DEVELOPMENT

Program, Institution or Department	Fiscal Year				
	1980-81	1981-82	1982-83	1983-84	1984-85
	(Million Dollars)				
Agricultural Research Service (NCSU & NC A&T)	18.3	20.0	21.2	21.3	21.3
Other UNC Programs	6.9	8.6	9.7	10.8	10.8
Dept. of Public Inst.	2.4	2.5	2.6	2.9	2.0
Dept. of Commerce	1.3	1.2	1.5	9.5*	12.3*
Nat. Res. & Comm. Develop.	1.8	2.3	2.4	2.2	2.2
Dept. of Human Resources	1.1	1.1	0.9	0.8	0.8
Dept. of Administration	0.3	3.3*	21.8*	0.3	0.3
Dept. of Transportation	0.4	0.5	0.5	0.5	0.5
Dept. of Agriculture	0.1	0.1	0.1	0.1	0.1
Dept. of Correction	0.1	0.1	0.1	0.1	0.1
Dept. of Comm. Colleges	0.2	0.2	0.2	0.2	0.2
Governor's Office	0.1	0.1	0.1	0.1	0.1
Total	33.5	40.0	61.1	48.9	51.7

*Includes $41.5 million for the Microelectronics Center of North Carolina over the four-year period beginning in FY82.

Table 1 does not include expenditures for the N.C. School of Science and Mathematics, since this is classified as education rather than R&D. Neither does it include expenditures for additional faculty members associated with developments in microelectronics, biotechnology and other new research initiatives. Federal and private support, whether with public or private institutions, is also excluded.

In the fields of agriculture and forestry, the Board made a more comprehensive review of R&D expenditures, a review that included sources of funding other than state appropriations and that identified expenditures by private institutions as well as public. Table 2 gives a summary of this information for FY80.

TABLE 2

TOTAL SOURCES OF FUNDING FOR AGRICULTURE AND FORESTRY
RESEARCH AND DEVELOPMENT IN NORTH CAROLINA, FY1980

Organization	State Approp.	Federal Agencies	Indust., Foundations, etc.	Total
	(Million Dollars)			
Agricultural Research Service (NCSU, A&T)	18.3*	7.3	3.7	29.3
Agricultural R&D other Than Through Agricultural Research Service				
Pub. Institutions	.3	1.4	.3	2.0
Pri. Institutions (Duke)	-	.9	-	.0
Total	18.6	9.6	4.0	32.2

*Estimated, based upon FY79 and FY81 data.

Source: Agriculture and Forestry Research and Development in North Carolina, FY79 and FY80 (Raleigh: N.C. Board of Science and Technology, 1981) pp. 9,42.

Table 2 illustrates that, whereas state funding of R&D in agriculture and forestry exceeds other sources of support, federal and private sources are significant. No doubt in medical, engineering and other fields, the other sources exceed state support, given the limited appropriations to other fields as shown in Table 1. Data have not been assembled, however, to document this possibility. It is therefore recommended that:

- Documentation of All R&D Expenditures

  The Board of Science and Technology should extend its documentation of all R&D expenditures to cover all fields of exploration by both public and private research institutions, and to include all sources of funding. Expenditures by the Board of $25,000 to $35,000 per year for two years would establish the basic information framework, thereafter $10,000 to $15,000 per year would be sufficient to keep it up-to-date.

With a clear understanding of the general nature, scope and purpose of R&D expenditures in North Carolina, it would then be possible to examine future needs and opportunities that require additional expenditures and to provide effective justification for state appropriations for particular purposes. Without question, strong basic research must be pursued. But even very basic research funded by NIH, NSF or private foundations normally is associated with a field of study with at least a general intent; sometimes a specific purpose is intended, such as seeking to control or cure cancer. And university administrators must make decisions regarding which departments and schools should be strengthened and which should be stabilized, reduced or eliminated within the overall framework of budget limitations. And legislative and executive branches of state government must, working with institutions of higher education, business and industrial leaders, workers and others, ensure that appropriate support is given to both basic research and those processes by which the results of research are effectively utilized in the interest of the people of the state.

One key element will be telecommunications. A state telecommunication system that will allow for the linking of the educational institutions and the corporate organizations with which they will need to communicate would greatly enhance the interaction between the two sectors. This same system or network is needed to provide for the exchange of information among the libraries which will be needed to meet the research needs of the scholars and researchers attracted to the state under this proposed program. Clearly support must be given to enhance libraries as well as laboratory facilities. The telecommunications links must be present for transmittal of electronic mail, interlibrary document delivery, and related cooperative functions.

States, through the joint effort of government, academia and the private sector, are finding it necessary to devise explicit R&D policy, as the NGA report noted above reveals. Thus, while North Carolina has begun the process of developing such policy, the approach needs to be extended and refined to be more comprehensive. In doing so, colleges and universities, private industry, local governments and state agencies must work together. State, federal and private sources of financial support must be woven into comprehensive policy objectives, rather than merely reacting to federal and private initiatives as implied in research program announcements and requests for proposals. No longer can it be assumed that federal decisions with respect to basic research objectives adequately reflect the needs of North Carolina, and that the results of basic research will inevitably be used effectively for the benefit of the citizens of the state. Therefore, the network of linkages between basic research projects and effective utilization of research results through technological innovation processes, as outlined in Volume II, must be visualized and supported as part of the overall state R&D strategy.

Three brief examples may be given of the importance of comprehensive R&D policy in North Carolina:

1. Microelectronics. By establishing the Microelectronics Center of North Carolina, three purposes are being achieved: First, basic research capability is being strengthened in six institutions[1] and essential equipment is being obtained and shared, thereby reducing the equipment costs per institution. Second, the unified effort of six institutions is providing a range and depth of research and education capability in this field that can compete effectively with any other area of the nation. Third, through the linkage with traditional industrial firms in the state, and with new high-technology firms within and outside the state, the Center is fostering the technological innovation processes that are essential to economic revitalization of North Carolina. No longer will we rely upon some undefined percolation process by which research results will be utilized.

2. Biotechnology. The North Carolina Biotechnology Center is establishing similar linkages between basic research scientists within our universities and the private firms, financial institutions and others that are essential to effective use of our scientific, engineering and technological resources in this field. Biotechnology is of great importance to the future of North Carolina, particularly with respect to agriculture and forestry, biomedical pursuits, industrial activity concerned with fermentation and other processes that can be enhanced through genetic engineering. Clearly, as soon as revenue conditions permit, the Biotechnology Center needs to be supported at a level comparable to that provided to the Microelectronics Center. Michigan, Florida, and other states are initiating comparable programs. Given the importance of agriculture, forestry and medical/health pursuits in North Carolina, it is essential that this state keep pace with rapidly changing developments.

3. Medical/Health Opportunities. Health care in the United States, with North Carolina as no exception, is paradoxical. On the one hand, the nation has outstanding medical schools and has pioneered medical research, punctuated by many Nobel awards. Yet, on the other hand, the health of the people of the nation is by no means as outstanding as our research achievements. As noted above, North Carolina has four medical schools and one school of public health, and many local public and private health facilities. Hence, the challenge before us is to make more effective and efficient use of the resources we have in improving the health of all citizens of the state. R&D policy in this field, linked via technological innovation processes with our public and private health care delivery system, is therefore essential.

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[1] Institutions represented on the Board of Directors of the Microelectronics Center are UNC-Chapel Hill, N.C. State, Duke University, N.C. A&T, UNC-Charlotte, and Research Triangle Institute.

Further Action Required

Because of the critical role research plays in education, economic development, health care, agriculture and forestry, and many other fields of concern for the people to North Carolina, the Task Force believes that the research enterprise in North Carolina's research institutions warrants particular attention. Any steps the state can take to enhance the research capacities of its universities will benefit not only the research institutions but also citizens throughout the state.

A comprehensive policy and associated implementation strategy for expanding North Carolina's research capacity will involve many of the major components of academic programs that are addressed in subsequent chapters of this volume. It will require additional facilities and equipment, the highest quality faculty members and graduate students and solid patent management programs. The following recommendations address the research effort most directly:

- Comprehensive Research Strategy and Associated Grant Program

  The General Assembly should invest $1 million annually in a major research grant program to support outstanding research in North Carolina's public and private universities. The program, administered by the Board of Science and Technology, would represent a significant expansion of the Board's present program, and would make awards to researchers on the basis of competitive proposals judged by a system of peer review. Research would be targeted to specific state needs, based upon a comprehensive research strategy.

- New Policies on Research Overhead

  - Chancellors of the University of North Carolina institution and Presidents of the private colleges and universities should return a portion of overhead allotments negotiated with research sponsors to the Principal Investigator for discretionary purposes. This policy would provide greater incentives for faculty members to seek research funding and would allow investigators to supplement their university budgets for such items as travel to professional meetings.

  - The General Assembly should allow the institutions in the UNC System to retain the amounts they receive from research sponsors for overhead costs. At present, 30 percent of overhead is returned to the state General Fund.

  - State agencies, in their research contracts with universities, should recognize the real costs of overhead, and should allow universities to charge overhead costs to state research grants as they do to federal research grants. At present, state research grants disallow any charges for overhead.

- Make Significant Additional Investments in Scientific Equipment

  - With the support of the Legislative Research Commission of the General Assembly and through the cooperation of the University of North Carolina General Administration, the N.C. Association of Independent Colleges and Universities, and the Department of Community Colleges, the Board of Science and Technology has completed an extensive study of the scientific equipment needs of the institutions of higher education in North Carolina. Details are given in a report of the Board. Investments required from federal, state and private sources to meet these needs exceed $360 million over a five-year period. An action plan should be developed by which these requirements are met.

- Provide Financial Support to the Field of Biotechnology on a Scale Similar to that in Microelectronics.

  - Plans for a strong program in biotechnology are being developed through cooperative efforts among universities, private industrial firms, a special Biotechnology Committee of the General Assembly, and the N.C. Biotechnology Center. They include much stronger programs in this field in universities, stronger support from industry, and appropriate functions and support for the Biotechnology Center. The total magnitude of investment required is expected to be somewhat comparable to the commitment to microelectronics--i.e. about $40 million over the next five years. Given the importance of research and development in biotechnology to agriculture, forestry, biomedicine, and other fields in North Carolina, serious consideration should be given to implementing the plan when completed. The Task Force Committee on Agriculture and Forestry has highlighted the importance of biotechnology in its report.

- Medical/Health Research and Health Care

  Given the medical/health research facilities in North Carolina, public and private, provision should be made for more effective interaction between research pursuits and health care delivery systems. The objective should be to significantly improve the health of all citizens of North Carolina, at all age levels, through more effective use of research results in innovative preventive and curative programs, public and private.

Chapter Four

MEETING THE NEEDS OF STUDENTS

North Carolina's institutions of higher learning fulfill their missions of service to the state in several ways -- by conducting research, by producing educational materials, by participating in community projects. But unquestionably their greatest contribution to the state is in nurturing and developing the potential of individual minds through education. In a real sense, then, the students passing through our colleges, community colleges, and universities are at the very heart of the educational enterprise.

The Task Force has identified several concerns relating to North Carolina's students, their preparation and their needs, and the state's demand for well-trained personnel. The recommendations presented in this section are designed to alleviate the most critical problems identified by the Task Force.

Pre-College Preparation

Without duplicating the discussion presented in Volume IV, it is appropriate to mention that higher education is vitally concerned with elementary and secondary education. The schools are the foundation of our educational system, and without their vital contribution, the work of the institutions of higher education would be impossible. Yet many of North Carolina's high school graduates are inadequately prepared for post-secondary study in science, engineering, and technology, hurting both the academic institutions and the state's economy. Higher education has three specific concerns. First, the pool of potential undergraduates in science, technology, and engineering is limited by the number of students taking prerequisite high school courses in science and mathematics. If North Carolina is to achieve preeminence in science and technology, the post-secondary institutions must prepare more technicians, engineers, and scientists; yet enrollment in high school science and mathematics courses is declining. Second, minorities are less likely to enroll in higher-level science and mathematics courses in secondary schools than non-minorities. Preparing minority students in science and mathematics at the pre-college level is key to increasing minority representation in science and engineering in our colleges and in our workforce. Finally, the poor preparation of students has forced many institutions to devote resources to remedial courses in science and mathematics, detracting from their primary mission of higher education.

A second area of interaction between higher education and elementary and secondary education is in the training of teachers. Teacher supply and quality is thoroughly discussed in Volume IV, but it is appropriate in this Volume to urge the teacher training institutions to adopt the recommendations in that Volume designed to improve teacher preparedness. Specifically:

- o Colleges and universities should cooperate with efforts to enable science and mathematics degree holders and professionals without teacher certification to obtain certification (Chapter Two, Volume IV).

- Colleges and universities should cooperate with efforts to produce more qualified teachers in high demand, critical shortage areas rather than areas of low demand and oversupply (Chapter Two, Volume IV).

- Colleges and universities that award primary (K-4) and/or Intermediate (4-6) Certification should require prospective teachers to complete satisfactorily at least three courses of three semester hours each in mathematics, three courses in science, and one course each in science methods and mathematics methods. A science and mathematics content area exam should be required for certification at these levels (Chapter Three, Volume IV).

- Colleges and universities offering Primary and/or Intermediate Certification should evaluate the coursework they offer in science and mathematics and, where necessary, develop content and methods courses specifically to meet the needs of elementary teachers in these subjects (Chapter Three, Volume IV).

- Colleges and universities should cooperate with efforts to create permanent summer institute programs in elementary science and mathematics education to upgrade the qualifications of elementary principals, teachers, and aides in the subjects of science and mathematics (Chapter Three, Volume IV).

- Colleges and universities should cooperate with efforts to create curriculum development projects through the developing network of Centers in Science and Mathematics. Each project should be tied to teacher education at the centers and involve a broad spectrum of participants, including teachers, in upgrading curricula for scientific literacy, for broad student interest, and for developing skills critical to success in a technological society (Chapter Four, Volume IV).

- The University of North Carolina should cooperate in efforts to establish Science and Mathematics Cooperatives in association with the Science and Mathematics Centers now being developed. These resource cooperatives should provide technical assistance to local schools in developing a master plan for improving instruction in science and mathematics, equipment and media sharing, equipment repair, and teacher training in the use of instructional resources, including new technologies and microcomputers (Chapter Four, Volume IV).

The Task Force believes that higher education, as well as the public schools, would benefit from prompt implementation of the recommendations presented in Volume IV.

Baccalaureate Education

Seventy percent of the baccalaureate degrees, and nearly half of the baccalaureate degrees in science, technology and mathematics, are granted by institutions in North Carolina that are not major research universities. These baccalaureate and comprehensive institutions are critical to the state's efforts in science and technology for two reasons. First, they educate almost half of the students who will be North Carolina's future scientists, engineers and mathematicians. Second, and perhaps more important, these colleges and universities bear a particular responsibility for educating students for life as well as occupation.

The college-educated citizens who receive their degrees from the comprehensive and liberal arts institutions undoubtedly will play a leadership role in North Carolina's assimilation of and adjustment to new technologies and the changes that accompany them. Many of the questions of public policy, corporate ethics, and personal values that new technologies bring will not require technical knowledge so much as social and humanitarian wisdom. The liberal arts institutions are particularly well-positioned to instill in their graduates a sense of moral literacy, culled from the contributions of the humanities and social sciences, as well as technical literacy. The Task Force views with approval the increasing number of "science, technology, and society" courses, which integrate social and humanitarian concerns with technological advance, and believes that this type of course is an appropriate part of the undergraduate curriculum. In addition, we reaffirm the importance of traditional humanities and social science courses in the undergraduate curriculum to provide a base for critical thought and a broad perspective for informed decisionmaking and personal fulfillment.

In addition, to operate effectively and to exercise leadership in a technologically complex society all baccalaureate students, regardless of their college major or intended career, must achieve basic competencies in all of the major scientific and technical fields. In Chapter Four of this report we call upon the institutions across the state to require all students awarded the baccalaureate degree to achieve competency in biology, chemistry, physics, mathematics, and computer science.

Finally, students who receive baccalaureate degrees in the science and technology fields form a pool of potential graduate candidates for the programs in the major research universities. Nearly half that pool receives its undergraduate training not in the research universities but in the comprehensive and baccalaureate institutions. For that reason, the comprehensive and baccalaureate institutions across the state must have the resources, particularly faculty and equipment, to provide excellent undergraduate education in the sciences and technology. In Chapter Five of this report the Task Force recommends special appropriations for science and technology faculty that will enable colleges and universities to hire new faculty and retain outstanding present faculty. We also present a program to improve faculty development. And in a related report, the Board of Science and Technology's Scientific Equipment Committee recommends a plan to upgrade scientific equipment for teaching as well as research.

The comprehensive and baccalaureate institutions form the backbone of our institutions of higher education. The challenge ahead in North Carolina will be to maintain and upgrade the capabilities of those institutions for educating students in the science and technology fields while accelerating the quest for excellence in the major research universities. The two efforts must go hand in hand. The Task Force urges all readers to join our commitment to achieving both goals.

Awareness of Educational and Career Opportunities

Many of North Carolina's students are unaware of career opportunities in science and technology and of the educational preparation needed to pursue them, precluding their entry into the science and technology workforce.

Every year many well-meaning applicants to North Carolina State University's School of Engineering must be rejected because they were unaware of the pre-college courses required for the study of engineering and failed to prepare themselves. Last year, the Community College System had to eliminate a program in radiation technology, a well-paying, high demand speciality in the medical field, because too few students signed up for the program. New college freshmen, unsure of their intended major, are often assigned to freshman advisors who may or may not know the options available in science and technology and the coursework needed to pursue them. In secondary schools, discussion with counselors suggests that students may be channeled into "vocational" coursework without rigorous science and mathematics classes as early as the 6th or 7th grade, effectively foreclosing their opportunities to study technical subjects at the post-secondary level. Based on examples such as these, the Task Force has concluded that traditional channels of advice and guidance, at both the secondary and post-secondary levels, are simply not working well.

A good flow of information to students about scientific and technical careers is particularly crucial for two reasons. First, preparation for most scientific and technical careers must begin early, with students taking science and mathematics courses throughout their high school years and during their post-secondary training. Without careful guidance, they may unintentionally foreclose the options of scientific or technical careers early in their school work. Second, scientific and technical advances are constantly creating new careers. Biotechnology technicians and microelectronics technicians are two examples of occupations which have come into being during the past decade. Students and their parents would be unaware of newer opportunities without some formal guidance program.

Training programs for elementary and secondary guidance personnel focus on psychological development and counseling and often include only one course on career decision making. As a result, few counselors are adequately prepared to guide students in career and coursework choices. Lack of time is an even more serious problem. With a statewide ratio of approximately one counselor to every 450-500 students at the senior high school level and one to 850 at the junior high school level, counselors find providing students with the individualized attention they deserve impossible. Furthermore, recent Federal laws and court mandates have diverted some guidance counselors away from their traditional responsibility for coursework-selection and career-selection advice to a plethora of special programs for "exceptional" children--gifted and talented, physically or mentally handicapped, emotionally disturbed. As a result, even counselors who are informed about scientific and technical careers lack the time to assist students making career choices. Classroom teachers, who can be a very valuable source of information on careers and educational requirements and who generally have more continuous contact with students than school counselors, are often not involved in career guidance and course enrollment decisions.

The counseling systems in the state's colleges, universities and community colleges seem to function fairly efficiently for students who have chosen a major field. For students who are uncertain of their career goals, however, the advising system can be arbitrary and even detrimental. Typically, an entering student will be assigned a faculty member as a freshman advisor based on that student's "expected" major. Faculty advisors are usually well acquainted with career opportunities and coursework options in their own fields. Yet, they are not career counselors by profession and may be ignorant of requirements in other fields. Students nationwide express dissatisfaction with college advisory mechanisms. A recent national study found that students considered career and academic advising the least satisfactory aspect of their college careers. Because preparation for scientific and technical careers usually requires concentrated study of science and mathematics throughout post-secondary training, students who are inadequately advised may find that they have unintentionally foreclosed their opportunities in science and technology in their freshman or sophomore years.

Like inadequate preparation, poor counseling affects minorities disproportionately. Many students learn about career opportunities through parents or through adult friends who are professionals in those fields. However, few scientists, engineers, and technicians are minority members; for example, only 1.6 percent of all employed scientists and engineers are black. Thus minority students generally do not have access to informal advice from professional acquaintances. The North Carolina Council for Minorities in Science, Mathematics, and Engineering, discussed in Volume IV, is an excellent vehicle for addressing the underrepresentation of minorities, and we urge colleges and universities to support that program.

Existing channels of career information, particularly with respect to scientific and technical fields, are inadequate, resulting in personal hardship and an inadequate flow of students into scientific and technical careers. Adequate career and educational counseling should be a part of every student's experience in the schools, colleges, community colleges, and universities. Furthermore, career and academic counseling should be an intrinsic responsibility of all educators.

Improvements are needed at both the pre-college and post-secondary levels. The Task Force's key recommendations call for annual parent-educator-student enrollment conferences, for a comprehensive program to improve the preparedness of secondary and post-secondary counselors, for increasing post-secondary admissions and graduation standards, and for the institutions of higher education to reorient their advising systems for freshman and sophomore students. Along with these core recommendations, the Task Force proposes several additional recommendations to upgrade the career decision making process at the elementary, secondary, and post-secondary levels.

The Task Force also believes that reliable labor market information, in a form accessible to parents, students, counselors, and teachers is a prerequisite for effective counseling. Therefore, the Committee's recommendations in Chapter Six, "Labor Market Information", are another vital component of an integrated career awareness strategy.

The Task Force's key recommendations are:

- Parent-Educator-Student Enrollment Conferences

  The State Board of Education and the General Assembly should mandate and provide the resources for annual parent-educator-student enrollment conferences for each child in North Carolina public schools. The purpose of the mandatory conferences would be to discuss the student's aptitudes, interests, and course of instruction, and, during the secondary years, his or her future educational and career goals. During the conference, the parents, student and guidance counselor or educator would draw upon the student's permanent record as a resource, and parents of secondary students would be required to approve their child's course selection for the upcoming year.

  In advance of the conferences, each school system should develop a booklet or brochure containing a general plan of study for various career directions (e.g., science and engineering, humanities, skilled technical, etc.) indicating recommended coursework in each secondary year for students with various career goals. The booklet would be given to parents at the conference and serve as a checklist helping parents to ensure that their children are receiving the prerequisites for their future work and study.

  Conferences would be conducted in the early fall for elementary students and in the late spring for secondary school students, and would require approximately $8 million annually to fund additional non-teaching contract days. Student or parent situations requiring special attention would be referred to the school guidance personnel.

  The program is designed to accomplish several important objectives:

  - introducing educational and vocational planning early in the educational process, as students are making initial decisions on coursework.
  - improving parental understanding of the consequences of course selection decisions and increasing their involvement in those decisions.
  - upgrading career awareness programs and capacities in the schools.
  - ensuring that students do not unintentionally foreclose career options by their choice of courses, particularly by failing to enroll in science and mathematics courses.
  - increasing participation by minorities and women in scientific and technical courses and careers.

o Improving the Preparedness of Counselors

The Task Force recommends a multi-pronged program, costing approximately $420,000 annually, to improve the preparedness of counselors to advise students on educational and career decisions. As part of the overall initiative, the Task Force suggests:

- that the Schools of Education place greater emphasis on career awareness and decision-making in their programs for students majoring in counseling, including adding courses (and faculty, if necessary) on career options and the educational prerequisites for various careers. Schools of Education that have not already done so should establish separate fields within their counseling programs for prospective community college counselors, with greater emphasis on vocational counseling and the needs of adult students.

- that the State Board of Education require at least two courses in career/vocational counseling, including instruction in employment trends, for new secondary school guidance counselors, and require courses in career/vocational counseling for certificate renewal for counselors who have not previously had at least two courses in that area. These courses should include some field work experience.

- that the community colleges require at least two courses in career-vocational counseling for their counseling personnel. These courses should include some field work experience.

- that the University of North Carolina system, the Department of Community Colleges, and the NC Association of Independent Colleges and Universities jointly develop and distribute a reference handbook of degree programs in the colleges and community colleges for the use of high school counselors. For each college, university, and community college, the handbook would list major fields offered and both the secondary and post-secondary coursework required for the major. It would be updated annually. The Board of Science and Technology could serve as facilitator of this project, at least in the scientific and technical fields.

o Increasing Post-Secondary Graduation & Admission Requirements

In an age of technological complexity, all students need a thorough grounding in science and mathematics. The institutions of higher education should require competency through the level of Algebra II and a rigorous grounding in the biological and physical sciences for admission to college. The same standards should be applied by the community colleges and technical institutes for placement in high technology training programs. These requirements roughly correspond to 3 units of mathematics and 3 of science at the high school level, but the rigor and quality of the courses are more important than the number of units.

Graduation standards (and, therefore, core curriculum requirements) must also be strengthened in mathematics and the sciences. All students awarded a baccalaureate degree should have achieved competency in:

- computer science (literacy and programming)
- biology
- chemistry
- physics
- mathematics.

Again the quality and rigor of the work is more important than the number of courses. Strengthening graduation standards across all senior institutions will ensure that all institutions -- research, comprehensive, and baccalaureate -- have a capability for educating students for technical literacy.

- Upgrading Post-Secondary Advising Systems

  The public and private colleges, universities, and community colleges should reorient their advising systems for students who have not chosen a major field. Greater reliance should be placed on professional career planning personnel, in conjunction and coordination with faculty members. Generally, this recommendation would apply to students at the freshman and sophomore levels. For students who have chosen a major field, the Task Force recommends continuation of the traditional faculty advisor system. The program would cost approximately $6.7 annually, primarily for hiring additional counseling personnel in the post-secondary institutions.

The Task Force also recommends:

- Programs for Parents

  Every junior high and middle school should conduct an annual program for students and their parents to explain the long-term consequences of choosing between "academic" and "vocational" coursework, and the importance of continuing enrollment in science and mathematics courses. Schools should make a special effort to reach all parents, including those who do not normally participate in school activities. The Task Force believes that parental understanding is particularly important for increasing the participation of minorities and women. Ideally, the program should be held just prior to the enrollment conferences.

- Career Exploration Units and Career Education

  The State Board of Education should require each junior high or middle school to institute a career exploration unit, including appropriate interest and aptitude testing and directed by professional career counseling personnel, as a mandatory part of each student's curriculum program. The Task Force urges the Board of Science and Technology to work with the Department of Public Instruction, the Employment Security Commission, and other interested groups and agencies to promote greater emphasis on career education in the schools, particularly in science and mathematics.

- Industrial Participation

  The institutions of higher education should work with major industrial firms that hire scientific and technical personnel to develop programs for college freshmen to highlight scientific and technical careers and to expand summer internship opportunities for science and engineering students. The Board of Science and Technology should use its catalytic influence in promoting industrial and academic participation. Industry and technical societies should also sponsor and participate in career awareness activities.

- Co-ops and Work-Study

  Industry should increase its involvement in co-op and work-study programs for students at the secondary, community college, and college and university levels. Such programs allow students to explore potential careers while providing them with valuable job skills and providing industry with valuable assistance.

- Media Programs on Career Awareness

  The North Carolina Center for Public Television, in cooperation with the Department of Public Instruction, should develop a career awareness series to be aired on public television and made available to the schools and communities, perhaps through community cable systems. The series might focus on scientific and technical careers. Short public service announcement-type spots should also be developed, for use on either public or commercial channels. In addition, professional societies and other interested groups should develop slide-tape shows highlighting scientific and technical careers for use in the schools.

- Council for Minorities

  The Board of Science and Technology, the Department of Public Instruction, the Department of Community Colleges and the UNC system should provide support to the North Carolina Council for Minorities in Science, Mathematics, and Engineering. The Council links local programs providing support to minority students interested in science and mathematics. (The program is discussed more fully in Volume IV).

- Educating School Administrators

  The Board of Science and Technology should work with the designers of the Annual Summer Leadership Institute for Principals to encourage school administrators to emphasize educational requirements for science and technology careers. The program should place special emphasis on the importance of increasing participation of minorities and women in science and mathematics courses.

- Flexible Curricular Programs

  The institutions of higher education should develop curricular programs that would enable liberal arts majors to switch into science or engineering at the advanced undergraduate or masters level. Such programs may require substantial cooperation among institutions, and might require more than four years of undergraduate study. The programs might focus upon minorities and women.

Worker Retraining

Due partially to technological change, thousands of workers in North Carolina's traditional industries will lose their jobs during the next two decades. Unless provisions are made to retrain them for new jobs created by technological advance, the state may face both a large unemployment problem and a shortage of manpower qualified for new high-technology jobs.

Today, nearly half of North Carolina's total manufacturing employment is in four traditional, low-wage industries: furniture, textiles, lumber and wood, and food. Yet according to the report of the Commission on the Future of North Carolina (NC 2000), those industries are likely to experience dramatic changes in the next two decades due to rapid capital investment in high-technology machinery and equipment. These developments, the NC 2000 report suggests, portend a relative decline in employment in the furniture and food industries, and an absolute decline in employment in textiles and lumber and wood products. The textile industry alone has already lost some 75,000 jobs during the past several years.

On the other side of the coin, high-technology, high-skilled industries like fabricated metals, electrical and nonelectrical machinery, tools and scientific instruments, chemicals, drugs, and plastics promise significant employment growth in North Carolina. Nationally, growth in advanced-technology industries is expected to create 7.1 million jobs during the next 20 years, and North Carolina, with its special efforts to attract high-technology industry, is sure to get its share of the new employment.

Workers who lose their jobs due to basic changes in the structure of the labor force, such as the decline of major industries, are termed "displaced." The crux of the displaced worker problem is that, during the transition toward a technology-intensive economy, there will be a mismatch between the skills and knowledge of the workers in declining industries and the requirements of jobs being created. Some forecasters estimate that the skills of 40 percent or more of the current workforce will become obsolete over the next two decades. The industries expected to lose jobs -- textiles and lumber and wood products -- traditionally employ low-skill, low-wage workers in production-type jobs. Data from the North Carolina Employment Security Commission reveal that 95 percent of all unemployed workers registered with the Commission in 1980 were unskilled, although three-fourths of them had production work experience, particularly in the construction and textiles industry.

The advanced-technology growth industries, by contrast, tend to employ highly-trained personnel. Even within traditional industries, more high-level skills are expected to be required as new technologies are introduced. Among the members of Massachusetts' High Technology Council, an association of high technology employees, the employee mix in 1980 was as follows:

Professionals:	34.7 percent
Technical paraprofessionals:	13.1 percent
Administrative/clerical:	21.5 percent
Skilled labor:	24.3 percent
Production workers:	6.3 percent

Another recent study entitled "The Economic Hope of the Microelectronics Industry" by Duke's Michael Luger estimated that the skill mix in North Carolina's budding microelectronics industry would be approximately 35 percent managerial and professional, 40 percent semi-skilled, and 25 percent unskilled. It is likely that even production-level jobs in these industries will require a fairly high level of technical literacy.

Worker displacement and retraining are among the most crucial and complex issues that will confront North Carolina during the next two decades. Yet the state cannot lose sight of the fact that job creation must precede worker retraining. To retrain the displaced worker for a position that did not exist would be a cruel hoax, and one that has been repeated too often in recent years in other parts of the country. For this reason, we urge the reader to examine the strategies for job creation presented in Volume II in tandem with the retraining recommendations presented below. We also direct the reader to Chapter Six of this Volume, which presents recommendations for enhancing the information available for identifying emerging occupations.

The Task Force recognizes that some displaced workers cannot be retrained for high-technology jobs, and believes that their needs must also be addressed as part of any comprehensive manpower strategy. The economic development strategies outlined in Volume II, with their emphasis on nurturing small growing businesses, will contribute substantially to the goal of providing meaningful employment for North Carolinians of all skill levels, including those who will not be retrained as technical workers. Although broader manpower concerns are beyond the mission and expertise of the Task Force, we urge the colleges, universities and community colleges to participate with public agencies and private industry in developing manpower programs and to contribute their unique resources toward developing the potential of the state's labor force.

Obviously, several sectors of North Carolina's economy -- including higher education, the public schools, state and local government, and the new and traditional industries -- have both a responsibility for and a stake in retraining North Carolina's workforce. The purpose in this volume is to address the role of the institutions of higher education -- the colleges, community colleges, and universities -- in this process.

The retraining candidate is a different type of student, with substantially different needs, than the traditional 18-22 year old college student. Retraining students are older, often hold full-time jobs and may be responsible for families. Seventy-seven percent of community college curriculum students work full or part-time, and a 1982 survey by the Department of Community Colleges reveals that conflicting job hours is the most frequent reason for dropping out. The non-traditional student will require greater flexibility and innovation on the part of academic institutions. Evening and weekend courses and part-time study would better accommodate the educational needs of students employed full time in industry.

The institutions of higher education can take several steps to address the problem of worker retraining, particularly as it relates to science and technology. Because this mission is somewhat new to the academic community, continuing experimentation and flexibility will be required to reach workable solutions. Nevertheless, the institutions must recognize their responsibility to the state of North Carolina, its employers and its employees, and commit themselves to sustained action in addressing the need for retraining the workforce.

The key recommendations are:

- Plan for Worker Retraining in the Community Colleges

  The 58 institutions in the Community College System should develop a unified plan for worker retraining. The plan should take into account the skill level and geographic distribution of displaced workers and the skill level and geographic distribution of emerging job opportunities. A unified plan will result in the most efficient use of state and local resources, eliminate the potential for needless duplication among programs, and ensure the quality of programs offered. A more comprehensive labor market information system, discussed in Chapter Four, would be a valuable tool for developing a unified approach to worker retraining in the community college system, but planning should not be delayed until a comprehensive information system is in place. The one-time cost of developing such a plan is estimated at $200,000.

- Industry Planning for Displaced Workers

  Private firms and industries, individually and through their trade organizations, should mount a concerted effort to identify workers and groups of workers likely to become obsolete, and, in cooperation with the academic institutions and other interested parties, develop plans for worker retraining. A pilot program, costing approximately $50,000, should be conducted within one of North Carolina's traditional industries. State government should share part of the cost.

- Unemployment Insurance for Persons in Retraining

  The Employment Security Commission should undertake the steps necessary to exempt unemployed persons enrolled in programs offering skills that will enhance their employability from restrictions under the unemployment insurance system. At present, persons enrolled in schools or colleges, except persons who are part of a Federal training program such as the Job Training Partnership Act, are ineligible to receive unemployment insurance benefits. The Task Force believes that all unemployed persons, not only those in Federal training programs, should be encouraged rather than penalized for enrolling in programs that would enhance their opportunities for reemployment, and that those persons should be allowed to retain their unemployment insurance benefits during training. Substantial research on labor market conditions and on the training programs themselves would be required. Because there may be the potential for abuse, only exemptions that are carefully designed to prevent abuse should be granted. The present system, however, unnecessarily discourages workers from taking responsibility for their own retraining, and therefore the ESC should work toward policies that would provide more positive incentives.

The Task Force also recommends:

- Expansion of Customized Job Training Program

  The Department of Community Colleges, with additional funding from the General Assembly, should expand its customized job training program to include the needs of existing industry for retraining and upgrading worker skills. Industry should share the costs of the program.

- Expansion of Technical Skills Programs

  The colleges, universities, and community colleges should expand their adult education programs in skill areas such as computer science that provide basic technological skills and prevent worker obsolescence.

- Maximum Use of Job Training Partnership Act for Retraining

  The Department of Natural Resources and Community Development, as it develops North Carolina's Job Training Partnership Act (JTPA) program, should make maximum use of the retraining provisions of the Act, particularly within the Community College System. The Task Force does not believe that the Job Training Partnership Act alone will be sufficient to stem the displaced worker problem, but the full resources of the JTPA's retraining title should be brought to bear on the problem in North Carolina.

- Policies for Adult Students

  The senior institutions and community colleges should adopt mechanisms, including class scheduling, child care arrangements, and admissions policies, to enable and encourage adult students to enroll in employment-related courses.

- Industry-Sponsored Courses

  The senior institutions should expand their offerings of industry-sponsored short-courses and seminars for upgrading professional skills. These programs would be analogous to the customized worker training program in the community colleges, and the costs should be borne partially by the sponsoring firm or industry.

- Post-Baccalaureate Professional Programs

  The senior institutions should expand the use of fifth-year and mid-career professional programs as a mechanism for retraining and upgrading professionals in fast-changing fields such as engineering.

- Support for Continuing Education Programs

  The institutions of higher education (and the institutional systems) should increase their support for continuing education programs in science, engineering, and technology to enable professionals and paraprofessionals in those fields to remain current in their disciplines and advance into new areas of knowledge.

Graduate Students

The high costs of graduate education and insufficient sources of graduate student support in North Carolina's universities may deter the most qualified students from pursuing advanced degrees in science and engineering in North Carolina, depriving the state of an important source of manpower for its advanced-technology enterprises and academic institutions.

The advances in research and industry that North Carolina will need to grow and prosper will be dependent on access to the best, most highly-trained minds. Advanced-technology firms look for a highly qualified pool of graduate talent from which to draw their employees, and the growth of high technology industry will require the expansion of many graduate programs to meet industrial demand. The state's traditional industries, such as agriculture, need the fresh insights of students trained in the most recent advances to help introduce new technologies into their production processes. Quality graduate programs also attract some of the nation's most brilliant young men and women to North Carolina, and many of them remain in the state to contribute to its industries and its tax base, and to the universities themselves.

The graduate students who pursue their advanced studies in North Carolina's universities represent a tremendous resource for the state. During their studies, the work they perform as teaching and research assistants permits the universities to conduct many vital teaching and research activities at a fraction of the cost for permanent full-time employees. More important, after graduation they become a readily-available source of talented personnel for the state's industries. As the state becomes more technology-based, high technology firms will judge North Carolina by the quality of the graduate students who will become their employees, and traditional industries will rely upon graduate talent to increase their productivity.

In general, the state's institutions have maintained excellent graduate programs, enabling them to attract able students. However, there are reasons to be concerned about graduate programs in North Carolina's universities. In the 1981-1982 school year, North Carolina's universities awarded only 45 doctoral degrees in engineering and only four in the computer sciences. At the master's level, only 183 degrees in engineering and 40 in computer sciences were awarded. An even smaller number of these graduates are actually available to meet the demands of the state's industries and academic institutions, because many are foreign nationals, about two-thirds of whom return home after completing their education. For example, at North Carolina State University, which educates 88 percent of the state's master's graduates and 62 percent of the doctoral graduates in engineering, one third of the master's candidates and 57 percent of the doctoral candidates are foreign nationals.

By almost any measure, the number of advanced-degree students in engineering and computer science is inadequate to meet industrial and academic needs in a state attempting to accelerate its high-technology growth and introduce new technologies into its existing industries. North Carolina's academic institutions are already facing serious difficulties in attracting qualified faculty members in engineering and computer sciences, partly due to an insufficient number of qualified new doctorates. (Chapter Five contains a more detailed discussion of this problem.) Science and engineering departments will have to be expanded to meet the manpower needs of advanced-technology and traditional industries with increasingly complex products and processes. As the academic departments grow, so will their demand for qualified faculty members drawn from the ranks of new advanced degree holders.

Most of the demand for highly-trained manpower, however, is likely to come from the private sector. A recent Congressional study of 691 technology-intensive firms revealed that the availability of a well-trained labor pool was the number one consideration in the locational decisions of the firms they surveyed. Although reliable estimates of the future demand of North Carolina's industries for masters and Ph.D. students are not available, a study done in Massachusetts can provide some clues. A rough extrapolation from a survey conducted by the Massachusetts High-Technology Council indicates that if the employment patterns of North Carolina's advanced-technology firms are similar to those in Massachusetts, the state would need over 2,500 graduates annually in mechanical and electrical engineering and computer sciences to fill the demand of high technology industry. By comparison, during the 1979-80 school year North Carolina's institutions produced only 351 electrical and mechanical engineers and 299 computer scientists. Even more startling, however, is that Massachusetts high-technology employers expected to hire two advanced-degree holders for every five new baccalaureate-level employees. North Carolina's institutions, by comparison, are now graduating nearly 7 baccalaureate engineers and nearly 6 baccalaureate computer scientists for every graduate-degree recipient in those fields.

North Carolina cannot rely on importing its manpower from other states because the lack of graduate-level engineers and computer scientists is national. In engineering, the number of Ph.D. candidates is on the upswing again after a decade-long decline, but Ph.D. production still does not approach the 1970 level of 3,681 per year. Furthermore, a substantial proportion of the new Ph.D.'s (around 37 percent) are foreign nationals. In the computer sciences, Ph.D. awards are fewer than 300 per year.

Both nationally and in North Carolina, women and minorities are underrepresented in graduate programs in the technical disciplines. Throughout the country, blacks received only 1.5 percent of the doctorates granted in engineering and 2.1 percent of doctorates granted in computer sciences in 1978-79. In the same year, women earned 3.8 percent of the doctorates in engineering and 11.2 percent of doctorates in the computer sciences. In North Carolina, none of the 44 masters and doctoral degree recipients in the computer sciences during the 1981-82 school year were black, and only 14 were women. In engineering one black and six women were among the 45 doctorates.

The reasons for the dearth of qualified students in engineering and computer science graduate programs are largely economic. Baccalaureate-level engineers can command starting salaries of more than $27,000, compared with graduate assistantships which average $5,586 at NC State and $4,067 at Duke.

At both public and private institutions, the costs of graduate education in science and engineering are outpacing sources of support for graduate students, jeopardizing the ability of North Carolina's universities to attract the finest graduate talent to this state. Federal student aid and R&D support has leveled off in recent years. Only institutions with large Department of Defense research projects are expected to reap benefits from the present Federal R&D budgets; North Carolina's universities are not among the major DOD contractors.

At the same time, the costs of graduate education in science and engineering have soared. The costs of building and equipping the specialized laboratories needed for graduate research in the sciences and engineering have skyrocketed beyond the general level of inflation. A study cited in "Emerging Issues in Science and Technology, 1981" (NSF) indicates that, in five important scientific disciplines, the costs of major instruments rose at an average annual rate of 20 percent between 1970 and 1978. The results of a leveling-off in graduate student support combined with soaring costs have been startling. At Duke University, graduate tuition has risen 168 percent since 1972-73, while the amount of financial aid per graduate student has increased only 48 percent. At Wake Forest, tuition has increased 125 percent while financial aid per student rose only 24 percent. Yet, the state's private institutions must remain competitive for the brightest graduate students because they serve a particularly valuable function in attracting talent from other parts of the country to the state.

North Carolina's public institutions, too, are experiencing difficulties in attracting and supporting the finest graduate talent. First, they are at a competitive disadvantage compared to other state universities in attracting the highest-quality graduate students due to the burdensome tuition remission procedure. In most other states, students awarded assistantships are automatically granted the in-state rate as an entitlement. In North Carolina, although the General Assembly has enacted a provision permitting remission (waiver) of out-of-state tuition for graduate students holding teaching and research assistantships, waiver of out-of-state tuition remains dependent on funding levels from year to year and from institution to institution. The result is a great deal of uncertainty, both for department heads and for prospective students in the UNC system, while institutions in other states are able to make firm and certain commitments.

Historically, tuition remission served as a budgetary limit, a cap on the total tuition waivers for out-of-state students in the UNC system. In the 1983 legislative session, however, the General Assembly moved toward providing adequate funds to waive tuition for all out-of-state graduate students with stipends of over $2,000 per year. Thus the burdensome mechanism seems to have outlived its usefulness as a budgetary tool, and is now only an administrative procedure -- one that may be hurting North Carolina's competitiveness for talented graduate students. Although there is no way to determine how many talented graduate students are actually deterred from pursuing graduate work in North Carolina because of the tuition remission policy, North Carolina is the only state with such a mechanism, and it introduces an unnecessary element of confusion into the recruiting process.

Coupled with burdensome tuition procedures for out-of-state graduate students is the spectre of increased tuition. Although out-of-state graduate students make up less than three percent of the University's enrollment, they are a particularly vital component of the University community. It is important to remember that other states have already absorbed the bulk of the educational costs of out-of-state graduate students through their elementary, secondary, and undergraduate years, and that North Carolina is reaping the benefits of their most productive years. Since tuition remission funds are insufficient to cover the out-of-state tuition costs for some talented graduate students even at the present tuition levels, higher tuitions could completely disable the University in its pursuit of the top tier of graduate students from across the nation. If that happens, it will jeopardize not only the quality of the University's graduate programs, but also the states's future economic capacity.

North Carolina's graduate schools are an essential source of personnel for the state's academic institutions and its burgeoning high-technology industries. However, the state's universities are graduating insufficient numbers of graduate-level engineers and computer scientists, and efforts of both our public and private institutions to attract the most qualified students are jeopardized by high tuitions and insufficient graduate student support. The following proposals are designed to prevent erosion in the state's ability to recruit and educate the finest graduate talent, and to redress difficulties facing the institutions. The key recommendations are:

- Investment in the Future Fellowships

  The state should sponsor and the General Assembly appropriate resources for "Investment in the Future" fellowships to support outstanding graduate students in engineering and the sciences. Emphasis would be placed on qualified women and minority candidates. The fellowships would enable North Carolina to increase its production of graduate-level scientists and engineers to meet anticipated industrial needs, and to encourage highly-talented students to pursue their graduate work in the state. The program should be built up gradually over a five-year period to a level of $.5 million annually.

- Moratorium on Increases in Out-of-State Graduate Tuition

  In the sciences and engineering, industrial and academic advance are almost wholly dependent on access to the most creative minds in the field. The University of North Carolina is in a highly competitive national market for the best qualified graduate talent and higher tuitions may deter the most qualified students from pursuing advanced degrees in North Carolina. The small investment the state can make in educating out-of-state graduate students is likely to be paid back many times over in service to the University, in technological advances, in expansion of the revenue base and in recruitment of high technology industries. For the benefit of the citizens and economy of North Carolina, the Task Force calls for a permanent moratorium on increase in the out-of-state tuition for graduate students in the University of North Carolina.

- Reforms in Tuition Remission

  The Board of Governors and the General Assembly should abandon the tuition remission mechanism and adopt a policy that automatically grants an in-state tuition rate to all out-of-state graduate students awarded teaching or research assistantships of over $2,000, and provide sufficient funding to implement this policy.

The Task Force also recommends:

- Industry Support for Graduate Students

  The industrial community, which is a prime beneficiary of the graduate talent trained in North Carolina's institutions, should provide financial assistance to outstanding graduate students in engineering and the sciences in North Carolina's universities.

- Federal Support for Research and Financial Aid

  The Federal government should maintain and increase its support for research and development (including non-defense R&D) and for student support, particularly for graduate students. Both research assistantships and financial aid will be essential for ensuring an adequate flow of students into science and technology graduate programs, which in turn is critical to ensure the nation's economic and military security. Furthermore, student support is needed to enable the economically disadvantaged to pursue graduate work. The North Carolina Congressional delegation, the National Governor's Association, and other groups representing the interests of North Carolina and its educational institutions should take an active role in promoting funding for research and student support at the Federal level.

The concerns discussed above -- Pre-College Preparation, Baccalaureate Education, Awareness of Educational and Career Opportunities, Worker Retraining, and Graduate Students -- are related in many ways, and improvements in each are needed to move North Carolina's educational enterprise forward into the 21st century. If the next generation of students is well-prepared, technologically literate and adequately counseled, the need for massive retraining will disappear as individuals with the capacity to continually upgrade their own knowledge base enter the labor force. As the quality of science and mathematics instruction at the pre-college level improves, and as elementary, secondary, and post-secondary counselors come to understand the importance of science and mathematics coursework, more students will be well-prepared in the technical subjects, increasing the number of potential new graduate students. These well-educated members of the skilled and professional labor force will in turn become advocates for strong pre-college programs and effective counseling for the generation behind them. But efforts must begin now if the benefits are to be realized in the future.

Chapter Five

MEETING THE NEED FOR QUALITY FACULTY

Many components contribute to an institution's effectiveness--its students, its facilities, its administrators, its campus life. But none is as key to the quality of its teaching and research programs as its faculty, the men and women charged with imparting their knowledge to the next generation of workers and scholars. Traditionally, North Carolina's institutions have attracted the finest teachers and scholars in many fields. However, the Task Force on Science and Technology has identified some disturbing problems which threaten the institutions' teaching and research programs in science and technology and thereby jeopardize North Carolina's bid for preeminence in advanced science and technology.

The combined efforts of government, industry and academe are needed to ensure the excellence of faculties in our academic centers, both public and private. Private industry, as a prime beneficiary of the trained manpower educated in our academic centers, must play an active role in assisting the colleges, community colleges, and universities to secure high-quality faculty members. Nevertheless, the institutions themselves, and the state government that supports them, must provide the leadership and initiative in responding to faculty needs in the scientific and technological disciplines.

Attracting and Retaining Quality Faculty in Science and Technology

North Carolina's public and private academic institutions must be able to attract and retain the highest quality faculty members if they are to maintain and strengthen the quality of their teaching and research programs. Yet North Carolina's colleges, universities, and community colleges are facing severe difficulties in building their faculties in several crucial fields, and may in the future experience difficulties in other fields essential to scientific and technical advance.

Nationally, there are approximately 1,650 vacant faculty positions in engineering. In the computer sciences, doctoral-granting departments report that they fill only 70 percent of new and replacement faculty positions available. North Carolina's institutions mirror the national situation. At North Carolina Agricultural and Technical State University and the University of North Carolina at Charlotte, for example, engineering faculty positions which are vacant or filled with non-permanent staff amount to ten percent of the budgeted positions. Departments of computer sciences also report stiff competition for qualified faculty members, as do specialized programs in advanced-science fields such as plant molecular biology. In the community colleges, the situation is more difficult to document, but technical training programs have faced increasing competition from industry for qualified instructors during the past several years.

Problems in attracting and retaining quality faculty stem from at least three sources: 1) inability to pay salaries commensurate with those in industry, 2) poor work conditions, and 3) an insufficient pool of potential faculty members. In engineering, for example, 1980-81 baccalaureate graduates were offered salaries of between $21,300 and $26,700 (depending on field). By contrast, assistant professors of engineering at NC State, NC A&T and UNC-Charlotte, most of whom hold doctorates, were paid an average of $23,083, $21,010, and $20,336, respectively (nine-month contracts). In the community colleges, the salary differential between industrial work and teaching for technical instructors is also widening.

An additional problem is salary compression; that is, as entering salaries for young faculty in these fields are bid upward in the marketplace, the differential between their salaries and those of established faculty members narrows, causing morale problems among older faculty. For example, the average differential between assistant and full professors in engineering at NC A&T is less than $7,000.

In most institutions, faculty compensation in the technical disciplines is further limited by written or unwritten codes requiring parity among all academic disciplines. Such policies severely restrict the institutions' freedom to respond to market conditions in setting faculty salaries. Basing funding on full-time equivalent enrollment compounds the problem, as discussed in Chapter Two. Moreover, North Carolina's public institutions experienced difficulties in retaining faculty members due to the legislative freeze on faculty salaries during the 1982-83 school year and the accompanying restriction on the use of non-state funds to raise faculty salaries. While the salaries of faculty members nationwide jumped an average of 7.6 percent between 1981-82 and 1982-83, North Carolina's university and community college faculty salary increase was zero. In the state's PhD-granting universities alone, at least 25 faculty members resigned during 1982 and 1983 citing the salary freeze as one of the reasons for their decision.

Outdated equipment, insufficient facilities, excessive administrative details and heavy teaching loads exacerbate the salary problem and exaggerate the differences between industry and academia. In North Carolina's public and private schools of engineering, the average piece of equipment is over ten years old, and approximately 11 percent of engineering equipment is over 20 years old. Given the pace of technological advance, much of this equipment is undoubtedly obsolete. (Readers should refer to the forthcoming report of the Board of Science and Technology's Scientific Equipment Committee for a comprehensive treatment of equipment issues.)

Usable space is also at a premium in the scientific and technological disciplines. At NC State, for example, the majority of the engineering buildings were built before or during World War II, and the newest building is now 20 years old. NC A&T boasts two engineering buildings, one built in 1955 and one built by the Works Progress Administration during the Depression. Even at UNC-Charlotte, the state's newest engineering school, the engineering building is nearly 20 years old. The computer and applied science fields, being relatively new and rapidly-growing disciplines, are without appropriate equipment and facilities. Research space is a particular concern, since in an age of advanced technology proper research facilities will differ significantly from classroom facilities and often must be built specifically for research activities. Cramped and outdated buildings hinder the recruitment of outstanding faculty members and thus inhibit the state's quest for scientific and technological excellence. Although the General Assembly has committed funds for a new engineering building at NC A&T State University, a computer science facility at UNC-Chapel Hill, and a physical sciences building at UNC-Charlotte, additional expansion and upgrading of facilities is still needed. North Carolina State University, particularly, requires a modern engineering research building if its engineering program is to reach national research stature.

Increases in regulations and data requirements have combined in recent years to impose ever-greater administrative burdens on faculty members. Several recent studies compiled by the National Science Foundation indicate that between ten and 30 percent of a scientist's typical work week may be accounted for by institutional or governmental administrative requirements. The unprecedented surge in undergraduate student enrollments in some technical subjects, although welcomed, has created additional hardships for both faculty and students in those fields. Since the mid-70s, for example, the size of a typical class at NC State's School of Engineering has increased from 20-25 to 50-60, and the typical advising load from 16 to 60 students.

Compounding the difficulty of hiring quality faculty members is the fact that the national pool of potential faculty candidates in several fields -- especially engineering and the computer sciences -- is limited. As discussed in Chapter Four, few students are seeking doctorates in engineering and computer sciences, and many of them may choose to practice in industry rather than the academic setting. A particular problem for academic institutions is the scarcity of minority and female faculty candidates in the technical disciplines. Nationally, only 1.5 percent of faculty members in engineering and seven percent of faculty in computer sciences are women. Implementation of the recommendations presented in the earlier section on graduate students will help academic institutions improve the quality of their faculties by increasing the pool of potential faculty members.

One vital component of North Carolina's technological preparedness is its capacity to educate the next generation of scientists, engineers and technicians who will form the vanguard of economic progress in the next decade. Faculty members who are highly knowledgeable and well-qualified in their fields are necessary both to educate the young technical and managerial leaders of the future and to perform the creative research that will stimulate technical advance.

The recommendations below address two critical problem areas: faculty compensation and the teaching environment. Along with the earlier recommendations concerning graduate students, they also address the need to increase the pool of potential faculty candidates. The commitment to quality faculty is the most important contribution a state and its people can make to quality higher education.

The Task Force's key recommendations are:

- Elimination of the Use of Faculty Salary Freezes and of Prohibitions on the Use of Non-State Funds.

  The salary freeze and prohibition on the use of non-state funds during the 1982-83 fiscal year hurt the UNC and Community College Systems' competitive position for faculty members vis a vis other institutions and industry. The loss of faculty members and potential new faculty members represents a permanent loss of educational capacity to those institutions, which will in turn limit the state's future economic potential. The Task Force believes that salary freezes are an inappropriate and short-sighted way to effect cost savings and that they ultimately result in costs that are much greater than the benefits of the short-term savings. The General Assembly should henceforth refrain from using faculty salary freezes and prohibitions on the use of non-state funds for supplementing faculty salaries as a means of budgetary savings.

- Special Appropriations for Science and Technology Faculty

  Special appropriations of $2 million annually would enable the research universities, engineering schools, and community colleges/technical institutes to compete with institutions in other states and private industry for superior science, computer science and engineering faculty and high-technology program instructors. The appropriations would be analogous to the special appropriations for scientific equipment made during the FY 79-80 and FY 81-82 legislative sessions, and like the equipment funds, would bolster the state's efforts to recruit high-technology industries by strengthening the quality of research and teaching in science and technology. The funds could be used to attract outstanding new faculty or to supplement salaries of outstanding present faculty members in both the community colleges and senior institutions.

- Competitive Salary Levels

  The General Assembly and the institutional systems must provide sufficient resources to respond to market conditions for qualified faculty members. The Task Force believes that faculty salaries must be allowed to respond to market conditions, enabling educational institutions to remain competitive with other users of highly-trained manpower, including private industry. The intangible benefits of academic life afford educational institutions some flexibility in competing with private firms; that is, academic salaries do not have to reach absolute parity with industrial compensation in order to attract well-qualified individuals into teaching. Nevertheless, if the disparity between academic and industrial salaries becomes too great, as is now the case in engineering, computer sciences, other advanced-science disciplines, and technician training programs, the academic sector will inevitably fall behind in its efforts to recruit and retain qualified faculty, jeopardizing the institutions' ability to educate the next generation.

- Facilities Modernization and Expansion

  The General Assembly, the institutional systems and the individual institutions should commit the necessary resources to complete the major program of modernizing and expanding space and facilities in engineering, computer sciences, and basic and applied sciences begun during the 1983 legislation session. Particular attention should be given to research facilities, recognizing that in an age of advanced technology, facilities for conducting research differ significantly from classroom facilities and therefore must be built specifically for research purposes.

In addition, the Task Force recommends:

- Merit Compensation

  The General Assembly, the Board of Governors, the Community College System, and the individual institutions should provide the public institutions greater flexibility to grant salary increases based on merit in addition to across-the-board cost of living raises. Every faculty salary increase should include some allotment for merit increases.

- Parity in Fringe Benefits

  The General Assembly and the UNC General Administration should develop a long-range plan to bring faculty fringe benefits in the public institutions to parity with those in other states.

- Industry Support for Faculty

  Industries, foundations, and private individuals should supplement faculty salaries in the public and private institutions through grants, endowed chairs, financial awards, and consulting and summer work opportunities.

- Upgrading Scientific Equipment

  The General Assembly should take immediate actions to implement the recommendations of the Board of Science and Technology's Scientific Equipment Committee for upgrading scientific equipment and improving administrative procedures for acquiring equipment.

- Technical Support Staff

  Resources for technical support staff (technicians, equipment repair personnel, etc.) should be increased in the scientific and technical disciplines. Presently, one technician is allotted for approximately 16 faculty members, and this ratio is entirely inadequate in the scientific and technical disciplines.

- Use of Professors from Industry

  Public and private institutions, especially community colleges and baccalaureate institutions, should make use of creative part-time, adjunct, and joint-appointment professors from industry, utilizing the specialized expertise that these individuals can contribute to academic programs in science and technology.

- o Sharing Faculty Resources

  The public and private research universities should extend the faculty resources of comprehensive and baccalaureate institutions through faculty loan and faculty sharing arrangements. Research university faculty can assist directly in teaching, research and public service on the other campuses, and also conduct faculty development activities for their colleagues who teach in the comprehensive and baccalaureate institutions.

Adding Young Faculty in Biological and Physical Science Departments

North Carolina's public and private colleges and universities are able to add very few qualified young faculty members to their biological and physical science departments, creating an imbalance in the age distribution of faculty members which may deter a generation of qualified students from entering academia and lead to the emergence of a future faculty shortage.

Because of slowed growth in student enrollments and low turnover rates among present faculty members, North Carolina's colleges and universities are able to create only a few new faculty positions in several academic departments, including biology and physical sciences. The present situation denies higher education the unique contributions of young faculty members in pursuing new lines of research and in conveying fresh ideas from their recent graduate studies to the next generation of students. In addition, today's glut may lead to tomorrow's shortage: as both faculty retirements and student enrollments increase in the late 1990s, the state's colleges and universities may be without sufficient faculty talent.

Nationally, a recent National Science Foundation (NSF) survey found that in Ph.D.-granting institutions, the proportion of recent doctorates -- those holding their degrees for seven years or less -- on the full-time faculty in science and engineering departments was 21 percent in 1980, down from 28 percent in 1974 and 39 percent in 1968. By contrast, the department heads surveyed considered 30 percent to be the ideal proportion of young faculty.

A large percentage of the existing faculty are tenured, leaving little growing room for future new appointments. The same NSF survey found that in the physical sciences the modal age is 40-49, while in the biological sciences and mathematics, it is 30-39. Fully 96 percent of mathematics professors who have held their doctorates for more than seven years are tenured, followed by 94 percent in the physical sciences and 86 percent in the biological sciences. Furthermore, recent changes in federal legislation require colleges and universities to raise their mandatory retirement age from 65 to 70, and most professors indicate a desire to continue teaching beyond age 65. As a result, even fewer new academic positions will be open to young faculty members.

North Carolina's institutions show similar trends to those nationally. Statistics from the UNC-General Administration show that for the 1981-82 academic year, the modal age of mathematics faculty members is 30-39 and of natural science faculty is 40-49. The modal age of non-tenured faculty in both mathematics and natural science is less than 30. In 1981, approximately 65 percent of the mathematics faculty and 71 percent of the natural science faculty were tenured. The combined data for mathematics and natural science show that approximately 69 percent of the faculty were tenured.

North Carolina's institutions are also expected to experience a leveling off or decline in overall student enrollments. According to recent projections of the Western Interstate Commission for Higher Education, the number of 18-year-old high school graduates (the traditional college-age population) in North Carolina is expected to decline 25 percent between 1979 and 1994. Although many factors may act to offset the actual decline in college enrollments, the basic situation for faculty remains the same: Few new faculty positions are likely to be created through either growth or turnover for a decade or more.

In the mid-1990s, however, the size of the state's college-aged cohort will begin to rise again. At the same time, the academicians hired in the 1960s will begin to reach retirement age. The Carnegie Council on Higher Education estimates that faculty turnover, as measured by combined death and retirement rate, will begin to increase in 1993 in the life and physical sciences, and 1995 in engineering. There is considerable concern in the education community and elsewhere that colleges and universities will be caught with a dearth of academic leadership just as a new wave of students enter the system.

Definitive actions are necessary to remedy the present situation and, more important, to ensure that the state's colleges and universities are not caught with a shortage of talented faculty to lead the next generation of students in the mid-1990s. Yet the Task Force does not call for drastic solutions. Instead we suggest several policy initiatives which, taken together, will gradually alleviate the imbalance in faculty age structure.

In addition to these specific proposals, the Task Force believes that the tenure system deserves attention in the years ahead. An evaluation of tenure is beyond the Task Force's mission and expertise. However, we urge North Carolina's public and private colleges and universities, individually and through their professional organizations, to participate in dialogues on tenure and its advantages and disadvantages for higher education.

The Task Force's key recommendation is:

o Early and Partial Retirement Incentives

The colleges and universities should develop early and partial retirement incentives for senior faculty members to free positions and resources for hiring new Ph.D.'s. The problem is particularly acute in mathematics and biological and physical sciences departments. Improving early retirement options available to senior faculty members is the best way to alleviate the imbalance in the faculty age structure. Two complementary strategies have been discussed: improved incentives for early retirement, and new strategies for partial retirement. The latter would allow senior faculty members to become part-time but retain their fringe benefits. The program would be self-sustaining; that is, the resources for employing new faculty members would be derived from the savings in salaries and benefits from senior faculty taking the early and partial retirement options.

In addition, the Task Force recommends:

- Education on Retirement Options

  The institutions and institutional systems should examine and improve information, publicity, and counseling on early-retirement options presently available to faculty members.

- Non-tenure Track Positions

  The academic institutions should make increased and more creative use of non-tenure track positions.

- Expand Adult Education Programs

  In order to increase the opportunities for new faculty and train future faculty, the academic institutions should expand adult, industrial-affiliated, and part-time graduate programs.

Improving Faculty Professional Development in Colleges and Community Colleges

Science, engineering, and technical faculty in many of North Carolina's non-research colleges and community colleges have insufficient opportunities to keep up-to-date with developments in their fields, threatening the currency and relevancy of instructional programs in the institutions that educate the vast majority of the state's students.

If North Carolina is to maintain its strong research base and economic vitality, particularly in the advanced-technology fields, students in the state's colleges, universities, and community colleges must receive the most current education available in the sciences and technical disciplines. Yet, in an era of tight budgets and highly-tenured faculties, faculty members in the scientific and technical subjects may not be aware of the latest developments in their fields, particularly in the public and private non-research colleges that educate nearly half of all undergraduates in the sciences. In the technical fields taught in the community colleges, industrial techniques are changing so rapidly that, unless instructors have an opportunity to renew their skills in the workplace on a regular basis, the methods they are teaching may become obsolete.

In North Carolina, there are two causes of the problem: lack of interest and lack of opportunity. At two conferences sponsored by the Board of Science and Technology and several North Carolina educational associations in 1980 and 1981, participants felt that administrators and, in some cases, faculty members themselves, place insufficient emphasis on faculty development activities. For example, many administrators and faculty members perceive faculty development activities as expendable during times of tight finances, and unlike elementary and secondary schools, few require professional development activities as a condition of employment.

The more widespread difficulty, however, seems to be a lack of opportunity and resources, even among faculty members and institutions that place a high value on continuing professional development. The UNC system, for example, has never had a formal sabbatical system. During recent years travel funds have been so scarce that many faculty members have had to curtail participation in professional conferences, even those in which they are scheduled to deliver papers. Private institutions have reported similar difficulties.

In the Community College System, development activities have also suffered due to lack of funding: for example, the December 1982 and January 1983 seminars of the system's Professional Development Institute had to be cancelled because too few participants were able to secure travel funds and/or substitutes for their classrooms in order to attend. More important, few technical instructors have been able to renew their workforce experience in order to keep their knowledge current with new industrial practices.

In North Carolina, some steps are being taken to address this critical need. In the Wilmington area, for example, General Electric and other leading companies have initiated a program to provide summer employment for both secondary and post-secondary instructors. The project serves two purposes: to increase the faculty member's knowledge base, and to supplement his or her academic salary, thereby encouraging the faculty member to remain in teaching. Nevertheless, much more remains to be done across the state.

The rapid pace of scientific and technological development demands that instructors in the technical fields continually update and renew their knowledge base. Every year, new scientific breakthroughs make yesterday's theories and concepts obsolete. If North Carolina is to remain at the forefront of technological growth, our students must be trained in most current ideas and techniques. To improve the state of faculty development activities, the institutions themselves must first be committed to faculty development as a major component of their educational programs. In addition, resources and opportunities must be provided to the institutions and faculty members to enable them to stay current in their disciplines.

The Task Force's key recommendation is designed to highlight the importance of faculty development and make the most efficient use of existing resources. Other recommendations make specific suggestions on the targeted allocation of additional resources to improve faculty development.

The key recommendation is:

- Faculty Development Program

  The Board of Science and Technology should initiate a program to highlight the importance of faculty development, particularly in the scientific and technical fields in community colleges and public and private colleges that are not major research institutions. The program envisioned by the Task Force would have several components:

- encouraging each institution to develop an explicit plan for faculty development in the scientific and technical fields, by meeting with administrators, providing examples of faculty development plans, and assisting in developing individual institutions' plans

- compiling and disseminating information on faculty development in North Carolina institutions and other institutions throughout the nation

- coordinating faculty development activities among institutions (e.g. between research universities and colleges, between senior institutions and community colleges, among institutions in one local area and between institutions and local businesses)

- holding workshops for disciplinary chairmen from institutions across the state to discuss interinstitutional faculty development activities

- conducting a small grants program to promote interinstitutional faculty development activities.

In addition to funding provided by the Board of Science and Technology for the 1983-84 fiscal year, approximately $20,000 in additional appropriations is needed during the 1983-85 period.

In addition, the Task Force recommends:

- Expanded Professional Development in the Community Colleges

  The Department of Community Colleges and the General Assembly should expand the faculty-related work of the Professional Development Institute and the development activities of the Program Services Division, with an emphasis on the technical fields supporting high-technology development.

- Professional Leave Systems

  The senior public and private institutions should develop and expand professional leave time systems to enable faculty members in all disciplines to pursue research investigations and remain current in their fields. Similarly, the Department of Community Colleges and the individual institutions should expand work leaves for instructors to update their skills in the industrial setting. Industry support should be encouraged.

- Adequate Travel Funds

  The General Assembly and institutional systems should provide additional funds for travel to enable college and community college faculty members to attend professional development activities that are already available to them. The investment needed to enable *faculty members to take advantage of ongoing activities would be small relative to the benefits for the institutions' teaching programs.*

- *Contributions from research universities*

  Public and private research universities should provide faculty members and other resources for faculty development activities at comprehensive and baccalaureate institutions and community colleges.

- *Industry participation*

  Industry should develop programs to allow college, university, and community college faculty to extend their knowledge of industrial practice through summer employment, joint research projects, etc.

- *Interinstitutional Academic Programs*

  Interinstitutional academic programs in science and technology that would enable individual institutions to take advantage of expertise and resources in other institutions should be developed. Advanced communication links have significant potential for facilitating this kind of program. Interinstitutional cooperative programs also offer the greatest potential for developing flexible academic programs that would enable liberal arts majors to switch into science or engineering at the advanced undergraduate or masters level, as recommended in Chapter Four.

- *Flexible Scheduling*

  Institutional administrators in colleges and community colleges should use creative scheduling (e.g., 4-day work weeks) to enable faculty members to pursue professional development activities.

During recent years, the General Assembly and the institutions of higher education have shown an increased willingness to invest in the facilities and equipment needed to attain excellence in science and technology in colleges, universities and community colleges. Those commitments must now be accompanied by an investment in the human capital, *i.e.*, the faculty members, who will lead and teach a new generation of young adults. By developing the strategies discussed above -- for attracting and retaining quality faculty adding new faculty in some disciplines, and improving faculty development -- North Carolina will make great progress in its quest for scientific and technological preeminence.

Chapter Six

MEETING THE NEED FOR LABOR MARKET INFORMATION

North Carolina's colleges, universities, and community colleges are not receiving sufficient information on present and expected labor market conditions to enable proper planning of programs and counseling of students, thus creating a potential for imbalance between the knowledge and skills of the state's students and the needs of the state's businesses.

Everywhere around us, there are exciting new interactions between business and academia: joint research, co-investment in new ventures, cooperative teaching and work arrangements. Yet in the midst of all this activity, one of the most fundamental links is missing. Just as patents and licenses connect university research to industrial application, reliable information on labor market needs should connect higher education's teaching mission with the private sector's demand for trained personnel. In North Carolina, the quality, timeliness, and accuracy of present data sources are entirely inadequate for this purpose.

The state's institutions of higher education need reliable and timely information on supply and demand in various occupations to carry out two of their most important functions: counseling students on occupational opportunities, and designing and evaluating education and training programs. Those two functions, in turn, are essential to ensuring that the supply of manpower trained in the state's institutions is adequate to meet the growing demands of businesses and industry for well-educated personnel. Planning and counseling will become even more crucial as the state's industrial composition shifts toward high technology, and the need for good labor market information will grow as well. The institutions unanimously agree that present labor market information networks are not meeting their needs.

Although both community colleges and senior institutions use labor market information for the same basic purposes, the types of information they require are quite different. The community colleges and technical institutes are vocation oriented. With the exception of their college transfer programs, the Community College System provides training for narrowly-defined occupational categories such as electromechanical technicians or biomedical equipment technicians. Furthermore, they tend to train for the specific needs of the local labor market in their own communities. All of their programs can be completed in two years; many take a year or less. For these reasons, the community colleges need information that is current, localized, and job-specific.

By contrast, the senior institutions generally have not regarded job training as their primary mission. In an era of fiscal stringency and high unemployment, however, they have recognized that an efficient use of resources demands cognizance of labor market conditions. With the exception of a few professional programs such as engineering, senior institutions do not educate their students for specific occupations. The job market for their graduates tends to be statewide or even nationwide, and most degree programs require many years (from four years for a baccalaureate degree up to nine or ten years for a Ph.D.) to complete. To meet their planning and counseling requirements, the senior institutions need long-term projections on a statewide or national basis which are aggregated into broad occupational categories.

The Labor Market Information Division of the Employment Security Commission (ESC) is the state's largest generator of labor market data, but its information falls short of the needs of the state's educational institutions. The ESC's Occupational Employment Series estimates current employment in each industry by occupational category, by surveying each of the state's major economic sectors in a three-year cycle. The cyclical nature of the survey means that the most "current" information on a given industry may be more than three years old; for example, the most recent survey of industries in the trade and transportation fields was taken in 1979. Also, the survey is voluntary and thus subject to the many biases inherent in voluntarily-provided information.

The ESC's Industry and Occupational Projections Series, which estimates future manpower needs by occupational category based on projected future employment in the state's various industries, could be very valuable for educational planning, but the projections are unreliable. First, the information is often outdated. For example, the most recent projections predict employment through 1985 but are based on 1978 data. Second, in order to protect the confidentiality of individual firms, some of the detail in occupational titles is lost in the published projections at the metropolitan and regional levels. Third, the system is slow to pick up new occupational titles.

The labor market information series are not published in a format that make them accessible to college personnel, particularly counselors. During 1982, the ESC participated in a Department of Defense-funded demonstration project to train counselors to use labor market information, but the project has now ended and additional funding is uncertain. The ESC also intends to publish a series of pamphlets on high-demand occupations for counselors, but that project is also on hold due to a lack of resources. Finally, the ESC's labor market information series do not pair demand projections with supply projections, so college and university planners and counselors are unable to determine whether a given field is oversupplied or undersupplied.

The ESC's ability to respond to state needs is limited by several external factors. Although it is housed within a state agency, it is 100 percent Federally funded and therefore must give first allegiance to fulfilling Federal mandates which may have little relevance for North Carolina. Also, the Division's Federal parent agency, the Bureau of Labor Statistics, has undergone severe budget cuts in the past two years. Under current fiscal conditions, additional Federal funding to enable the Division to improve or expand its output is unlikely.

Most of the "supply" side of manpower information on college-educated personnel comes from the institutions themselves. In North Carolina, the colleges, universities, and community colleges do a good job of collecting basic enrollment and degree data, but they do a poor job of after-graduation employment follow-up. Simple information on where and in what capacity former students are employed would provide valuable clues on labor market conditions. Furthermore, knowing the occupations of graduates in various fields would make the analytical transition from degree data to occupational supply less difficult. For example, if one knew that historically only one-half of baccalaureate biology majors actually become professional biologists, predictions of the future supply of biologists would be considerably more accurate than if one assumed that all biology graduates entered biology as a career. This kind of information is presently unavailable, however, because the state's colleges, universities and community colleges do not collect uniform annual follow-up data, and collection efforts by individual institutions are spotty.

The State Occupational Information Coordination Committee (SOICC), and the affiliated National Occupational Information Coordinating Committee, were created by the Vocational Education Amendments and the CETA Amendments of 1976 to improve coordination between producers and users of occupational information. In North Carolina, the SOICC does not do any original data collection but concentrates on coordinating and disseminating information that is already available. The SOICC has developed an on-line, interactive career counseling program (CHOICES) which contains information on employment outlook and educational requirements for many occupational categories. It is now available in over half of the community colleges and is likely to be available in some of the senior institutions in the near future. However, because the SOICC does not collect its own data, the usefulness of its products are limited by weaknesses in the data bases it uses. For the occupational categories of greatest interest to higher education, SOICC relies primarily on demand data from the ESC and supply data from the institutions themselves, the limitations of which have been discussed above.

Many business associations also collect labor market information. The Raleigh Chamber of Commerce, for example, periodically surveys its membership on their expected needs for skilled labor. Although this type of survey has proven valuable to educational institutions, its results are only applicable to a local area. Other Chambers of Commerce around the state have expressed interest in conducting similar studies, but they have lacked the necessary staff and start-up funds.

Other business organizations collect labor market data for specific industries. The Massachusetts High-Technology Council, for example, has estimated the demand for skilled laborers, technicians, and technical professionals in that state's high-tech industries. No similar survey has been performed in North Carolina.

The Task Force joins the growing sentiment for reform of the state's labor market information systems. We particularly applaud the Governor's recognition that "a labor market information system is essential for the design of education and training programs to meet the needs of our expanding economy" and his creation of an Oversight Committee for Official Labor Market Information and accompanying Labor Market Information Office in the Employment Security Commission. The Task Force supports the Office and the Oversight Committee as they attempt to fulfill their mission of designing a comprehensive labor market information system for the state.

Many of the Task Force's recommendations are directed toward the Oversight Committee, because their work has the potential to resolve many of the difficulties identified herein. The Task Force's key recommendations are:

- Feasibility Study on Revising Unemployment Insurance Form

  One of the potential reforms that will be considered by the Labor Market Information Office and the Oversight Committee is a revision in the Unemployment Insurance reporting form. Under the present system each employer is required to submit to ESC a quarterly report which contains each employee's social security number and wages paid during that period. The information is used to determine the employee's eligibility for unemployment benefits should he lose his job. The proposed reform would add one line -- occupational title -- to that form. Because the report is mandatory rather than voluntary, a high percentage of employers would participate.

  If feasible, the proposed change has vast potential to improve the quality, timeliness and accuracy of the level of information that is currently available. However, a full assessment of the total costs as well as the benefits of the system is needed before attempting to put it into practice. Therefore, the Governor's Oversight Committee on Labor Market Information and the ESC's Labor Market Information Office should conduct a comprehensive feasibility study on the concept, and then proceed toward implementation if appropriate. The estimated cost of a comprehensive study would be $100,000.

- Special Manpower Studies

  The Oversight Committee and Labor Market Information Office should conduct a series of special studies including:

  - the labor needs of high-technology business in the state
  - the labor needs of new and expanding industries in the state, and,
  - a local-based demonstration study, similar to the Raleigh Chamber of Commerce's surveys, of all professional and non-professional manpower needs in a specific local area to serve as a model for other localities.

  In making this recommendation, the Task Force realizes that a comprehensive system may not be forthcoming until 1985 or later, and that many education and training decisions will be made in the interim. Furthermore, even when a comprehensive system is in place it will not provide detailed information on high-priority sectors of the economy such as high-technology industry and new and expanding industries. The local-based study is important for providing a model for local areas to meet their own detailed manpower information needs. The estimated cost of this recommendation is approximately $50,000 for each study.

The Task Force also recommends:

- Special Attention to the Information Needs of Higher Education

  The Governor's Oversight Committee and the Labor Market Information Office should place special emphasis on determining and responding to the needs of users in colleges, universities, and community colleges, and to give particular attention to dissemination networks.

- Re-examination of Confidentiality Policies

  The Governor's Oversight Committee should examine policies on confidentiality in the dissemination of labor market information, with the objective of allowing state agencies to have access to information for planning that is not made available to the general public.

- Continued Monitoring of Labor Market Information Reforms

  Board of Science and Technology should continue to monitor the work of the Labor Market Information Office and the Oversight Committee, particularly with respect to the needs of higher education.

- Informing Higher Education on LMI Policymaking

  The institutions of higher education should be made aware of Labor Market Information activities so that higher education can become an effective force in decision making on labor market information.

- Improved Labor Supply Information

  The community colleges and senior institutions should begin to collect standardized information on employment and occupations of former students.

Chapter Seven

TAPPING INTERNAL RESOURCES

Under the vigorous leadership of Governor James B. Hunt, Jr., the State of North Carolina is striving to achieve preeminence in high-technology industry as means of securing economic growth and prosperity. Other states, too, are recognizing technology's unique potential for job creation and growth, and the competition for high-technology development is becoming intense. North Carolina, with its favorable climate, low cost of living, and positive attitude toward business, is well-positioned to capture an additional share of the high-technology business. But there is certainly no cause for complacency. On the contrary, North Carolina must continually search for ways to maintain and increase its competitive edge.

Putting the Task Force's recommendations into action will require dedicated effort and substantial resource commitments from government, industry and individual citizens. Yet the Task Force also recognizes that the institutions themselves have an obligation to develop their internal resources to strengthen their educational and research programs. During the course of its discussions, the Task Force identified two mechanisms -- Industrial-University Research and Assistance Plans and Effective Patent Management -- that could allow the state's colleges and universities to supplement their educational resources while furthering their academic goals.

Two caveats must be kept in mind. First, North Carolina's colleges and universities are not profit-oriented institutions, and their primary missions must continue to be education, research, and public service. Any revenue-generating schemes that detract from or are not compatible with the primary missions are not acceptable, and the mechanisms proposed were explored with that concern in mind. Second, these proposals are not panaceas. At best, they will supplement traditional sources of income, and, because they are largely untried, their real revenue potential is unknown. Nevertheless, the Task Force urges the institutions to consider the ideas put forth here, adapting them to their own institutional structures and objectives, because they hold significant promise for strengthening the educational enterprise from within.

Industrial-University Research and Assistance Plans

The boom in high technology has caused many states to reexamine the partnership between universities and industries. In those states that have most successfully nurtured high-technology growth, superior engineering schools have provided the essential link between new ideas and innovative new industries. Imbued with the entrepreneurial spirit, engineering programs at such institutions as MIT and Stanford have served as the catalyst for spawning high-technology industries and creating thousands of jobs. North Carolina should expect no less of its engineering programs.

Yet North Carolina's schools of engineering find themselves facing unprecedented challenges, struggling just to maintain their present positions rather than striving for the excellence needed to move the state's technology-based industries forward. Faculties are poorly paid and carry heavy teaching and advising loads. Equipment and facilities are outmoded. Under these conditions, the engineering schools find themselves unable to attract and retain the caliber of faculty needed to build programs which will support the state's high-technology growth.

The obvious solution is more money, but state government resources are limited. What is needed is a way to tap the vast expertise represented within the engineering schools to enable the schools to help themselves while assisting the state's industries. The Industrial-University Research and Assistance Plan is designed to do just that.

An Industrial-University Research and Assistance Plan would accomplish six major objectives:

- provide organized access for industry to the specialized expertise, facilities, and equipment of the engineering school;
- bring in revenues to support the engineering school;
- provide practical, hands-on experience for students working on actual industrial problems;
- attract and retaining capable educators, by providing an avenue for salary supplementation;
- provide an avenue for faculty development; and,
- generate support for research by young faculty members.

Each institution must be given flexibility to develop its own organizational arrangement based on its unique strengths, interests, and missions and on its own internal structure. However, the plans are expected to share some common characteristics. The plans would contract with private industry for work to be performed by faculty members (and their students). The plan concept is broad enough to encompass both short-term problem-solving and long-term exploratory research. Patent agreements would be negotiated on an individual basis in accordance with university policy. Revenues would accrue to the school, to individual departments, and, indirectly, to individual faculty members.

This organizational arrangement would differ from traditional faculty consulting in several important respects. First, the plans benefit the schools' teaching mission by providing clinical experience for students. Second, work could be conducted by faculty and students on campus, enabling them to offer services to private industry which require the specialized equipment and facilities of university laboratories. Third, and most important, the plan revenues would accrue to the school of engineering for upgrading its programs and facilities, as well as to individual faculty members.

The presence of an Industrial-University Research and Assistance Plan on campus will entail recognition that the state's engineering schools contribute to industrial development along with performing their teaching and research functions. Because the university would be offering a new set of services for industry, a small amount of flexible start-up funding outside the institutions' teaching allotments would be required for administrative/development activities. Given sufficient flexibility at the outset, we believe that the plans could become self-sustaining in a very short period of time.

The Task Force is calling for a trial of the Industrial-University Research and Assistance Plans in the state's public engineering schools. The engineering schools are a logical proving ground for the concept because several of them are already considering similar ideas and because they have longstanding, formal relationships with industry. Our intent is that, if successful, the model should be extended into technical and non-technical disciplines at other institutions, including the community colleges, throughout the state. Therefore, the Task Force recommends:

- Industrial University Research and Assistance Plans

  The University of North Carolina engineering schools should proceed with all deliberate speed to create pilot Industrial-University Research and Assistance Plans compatible with their individual structures and missions. Seed funding for the plans would cost between $30,000 and $75,000 at each school during each of the first two to four years, but thereafter the plans should be self-sustaining.

Patent Management

During the past five years, almost every major research university in the country has reexamined its patent policy and patent management capability. The sudden flurry of activity following a long period of dormancy was the result of a confluence of events at the national level. First, the advent of biotechnology focused national attention on the interdependence of academic researchers and their brethren in the business world and fostered a plethora of new university/industry arrangements. Second, the passage of the Patent and Trademark Amendments of 1980 for the first time gave universities the right to hold patents on new ideas developed under Federal funding. Third, a prolonged recession and perceived stagnation in industrial innovation added greater urgency to the need to get academic research "off the shelf" and into the hands of potential commercial users. Finally, university budgets have been severely strained by cutbacks in federal research dollars and educational assistance, and many universities are looking toward patent royalties as a way to supplement their revenues.

In the university setting, a comprehensive patenting system will encompass two interrelated but distinct components. First, the university must develop a patent policy, specifying in advance the university's guidelines relating to inventions arising from academic research. Patent policies usually address such issues as:

- who (university, researcher, or funding source) will hold the patent rights to new ideas developed through academic research and under various conditions.

- what types of licenses can be issued on university-held patents, and conditions for issuance.

- procedures university employees must follow in disclosing potentially patentable discoveries.

- distribution of potential revenues from inventions or discoveries made in the course of academic research (e.g. among the inventor, the inventor's laboratory, the department, the university, and the sponsor).

- publication of research results when patent rights are involved.

The less publicized, but equally important component of a comprehensive patenting system is the university's patent management operation. The patent management system is the set of arrangements whereby the university ensures that, where appropriate, new ideas generated in university laboratories are moved quickly and efficiently into the commercial marketplace. Proper management of inventions also benefits the University directly by exploiting the commercial potential of academic inventions and thereby generating funds for research and education. Although university patent policies are obviously extremely important, they are meaningless without a strong patent management capability to put them into operation.

Like universities throughout the country, all of North Carolina's research universities have reexamined and revised their patenting systems in the last few years with the objective of accelerating technology transfer to the private sector and maximizing patent revenues. Three years ago, Duke University completely revamped its patent management operation, consolidating both the University and Medical Center patent activities under a single Patent Administrator. The Administrator's responsibilities include, among other things, "evaluating potential commercial use and investigating possible courses of action for patenting and/or marketing inventions in which the University has an equity" and "negotiating patent licensing and technology transfer agreements." Although Duke had previously used the services of the Research Corporation, a large national patent management organization, its new patent policy makes it abundantly clear that, "The University has created an Office of Patent Administration to manage all inventions assigned to it under this policy, and it does not anticipate assigning any such inventions to an existing patent management organization such as Research Corporation." Duke's patent office presently consists of a Patent Administrator, an administrative assistant, and a secretary.

Wake Forest University developed its first patent policy last year, for the first time bringing the University and the Medical Center together under one uniform policy. Bowman Gray Medical Center had previously handled patent management on an ad hoc basis, sometimes contracting with the Research Corporation and sometimes working with individual patent attorneys. Wake Forest has recently entered into an agreement with Duke University whereby its patent management needs are being handled by Duke's patent office.

The University of North Carolina also has recently approved a new patent policy. The new policy provides that inventions resulting from research at a constituent institution will normally be the property of the institution. It also specifies that the inventor will receive a minimum of 15 percent of the gross revenues derived from his or her invention, and it allows the University to issue exclusive licenses and delay publication for up to 90 days under some circumstances.

However, the new policy does not specify a patent management system, leaving patent management at the discretion of each institution to "administer its own patent management and licensing program" or "negotiate with reputable agencies or firms to secure for each institution arrangements for patent management." The University is weighing the options for patent management and is considering developing an in-house system.

In its deliberations, the Task Force considered several types of patent management arrangements, including:

1. Ad hoc
   Smaller universities may not need to develop any formal patent management arrangement, and simply handle inventions on a case-by-case basis, either by contracting with a patent management organization or by pursuing patenting and licensing on their own.

2. Patent Management Organizations (PMO)
   Patent Management Organizations are private non-profit or for-profit firms which specialize in performing patenting and licensing services for universities. Contracts may be exclusive or non-exclusive; that is, the University may agree to disclose all of its inventions only to the patent management organization or it may retain the right to disclose them at its discretion. PMO's usually provide their services "free of charge" in return for an agreed-upon percent of gross royalties, typically 20 to 45 percent.

3. In-House Patent Administration
   As the technological revolution proceeds, more and more major research universities are moving to set up their own patent management operations. In multi-institutional universities, one organization may perform patent management services for the entire system.

4. Independent University-Affiliated Foundation
   In some institutions, notably the University of Wisconsin, patent management is handled by an independent foundation. Although the foundation supports the University through an annual block grant for research and occasional special grants for buildings, it is not responsible to or controlled by the University (or the state legislature) in any way. University researchers are not required to assign their inventions to the foundation.

5. Public Corporation for University and Non-University Patent Management
   In England, the National Research Development Corporation (NRDC) acts as a public patent management organization for both

> universities and private inventors. Like PMO's, the NRDC undertakes patenting and licensing at no charge in return for a percent of royalties. In addition, the NRDC will support additional R&D costs where necessary, and it is willing to invest equity and loan capital in firms started to exploit an invention or new technology.

Proper patent management will accomplish two important objectives: strengthening the universities and accelerating technological innovation. North Carolina, with its concentration of public and private university research institutions, is in a unique position to experiment with jointly-managed patent arrangements. A cooperative patent management office should be attractive both to the universities, because it enables them to realize economies of scale and provides a "critical mass" of patentable ideas, and to the private sector, because it provides a one-stop shop for private firms seeking innovative ideas. One potential benefit of such an organization would be a better understanding of patenting policies across university-industry lines. The ideal patent management organization would serve both the universities and private inventors as a way of stimulating technological creativity throughout the state. However, patenting is a complex enterprise, and many factors need to be studied before any new organization is put into place. Therefore the Task Force recommends:

o Study of Patent Management

A comprehensive design study of patent management capacity in North Carolina should be conducted, giving particular attention to creating a patent management organization that would serve both the universities and private individuals and companies in North Carolina.

CONCLUSION

During the decades ahead, science and technology will change the pace and composition of our world and our lives. The role of the Governor's Task Force on Science and Technology is to ensure that all of North Carolina's resources are marshalled toward directing that change in positive ways for the citizens of our state. Higher education is but one part of the structure, but if the recommendations put forth in this volume are adopted, higher education can be a strong and positive force for the beneficial use of science and technology in our lives. The Task Force challenges our state's other institutions, including higher education, industry, government, the schools and the citizenry, to join with us in shaping this better future.